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Temporary Illumination in Engineering Work.

One of the problems frequently confronting the constructor is the adequate illumination of work on which night labor is required. It is extremely difficult to get good results without good light, even supposing the roughest operations; and if skilled labor is to be employed after dark, as is sometimes necessary, first class illumination must be secured unless much work is to be wasted. One may even go further and say that such operations furnish one of the very few fields in which a large measure of light is advantageous. The reason is not far to seek, for almost all the materials of construction are dark in hue, the background of the earth is also dark and there are apt to be many local shadows. Not long ago the smoky kerosene lantern was about the only available resource in such cases, and the workmen were barely able to see their picks. It is small wonder that often such work runs high in cost when a contractor pays extra wages, as often happens, and then handicaps his workmen by making them work well nigh in the dark. The next stage came with the Lucifer and similar petrol torches, which are still in considerable and useful employment. They produce a powerful and economical light, but one which flickers badly and does not lend itself readily to use in contracted spaces or to concentration by reflectors. The next step came with electric lighting, and arcs secured from local companies have been largely and successfully, but seldom effectively and economically used.

To light a large space where miscellaneous work of construction is going on is no easy task. The main thing is to get a powerful illumination without dense shadows, and well distributed over the space employed. On the whole the best result is obtained by lighting as far as possible from above in order to keep the glare of powerful lights out of the workmen's eyes. The cheapest forms of light are in large units so that economy requires their use except in rare instances. A street railway working a night gang on its tracks probably has the best facilities for good lighting. It merely has to connect groups of five or six incandescent lamps in series under a tin reflector and hang the bunch to the trolley wire with the other lead on the rail. For even and powerful light most convenient to the work, this arrangement cannot be beaten. The average engineer, however, has no such resource. His choice is generally between using gasoline and taking lights of the local electric company. Probably the best and cheapest form of the former plan is to use a group of mantle burners, the so-called "gas arc," employing gasoline gas from a pressure tank. Using a flexible tube for connection such a light can be and should be swung ten to fifteen feet up with an enameled reflector over it—moderately low in small areas, and higher in large ones where it is reinforced by its neighbors. This is certainly, power for power, the cheapest light for temporary use, easily beating out the electric arc, particularly the enclosed arc now used. The new "flaming arc" occasionally seen in use on our city circuits, is the only thing that can beat the gas arc at its own game, but this is now exploited at such fancy prices and the electric supply companies are so loath to push it on account of its enormous efficiency, that it cannot be considered as yet an available source of light for ordinary use.

If in working over a big area, where very powerful lights are wanted, arcs can generally be supplied by a short run from the nearest local circuit. If a direct-current arc circuit is available, it is best to use the old-fashioned open arc, preferably fitted with ⅜-in. carbons if the hours of burning are not too long. Such arcs give very much more light for the same energy than do the usual enclosed arcs; and as they may be had second-hand cheap they may well be picked up by the wide awake contractor. They should be adjusted for about 6.5 amperes ordinarily, this being the current commonly carried in direct-current lamps. If only alternating current is available, it will be necessary to be content with the ordinary arcs. In any case, arcs should be hung fairly high with reflectors over them, perhaps one arc to a space of 50 to 60 ft. square in the open, or spaced a little closer in narrow quarters where neighboring lamps do not much help each other. Arcs lend themselves readily to use with reflectors and in certain cases where they are not easily placed near the work, should be thus fitted. They should be used not singly but in pairs so as to give cross lights on the working space, thus decreasing trouble from shadows. In case reflectors must be used where an electric circuit is not available, a portable acetylene generator is the best source of light, being better in such case than the gas arc, although rather more costly. Reflectors of both wide and narrow angle should be available to meet the cases of a wide space or a deep excavation. With a few acetylene outfits and a number of gasoline equipments, the engineer can meet almost any exigency without calling for electric circuits. Eventually when the flaming arc comes into more common use it will be extremely well fitted for temporary works, and the small portable electric outfits may be thus utilized to very great advantage. Indeed, in many situations such a plant with, say, a 5-kw. generator, is extremely valuable to the contractor and can be worked at very moderate cost. Whether gasoline or electricity is the main reliance, the chief thing is to give steady light and plenty of it. It is easy to lose $5 in labor while saving 50 cents in light.

Margin for Improvement of the Steam Engine.

Science has been defined as classified knowledge, or facts arranged with reference to their relationship. Certain it is that no condition is more important for the study of any problem than the orderly arrangement of all facts bearing upon it, and their reference to such fundamental principles as may serve to bind them into a coherent whole. Nowhere is this more forcibly illustrated than in the study of the conditions affecting the improvement of the steam engine, or more generally the steam power plant as a whole. During the past hundred years and more the steam engine has been made the subject of numberless modifications and improvements, all looking toward a higher measure of economy. It will be of interest to consider briefly the more important of these various improvements with reference to the cycle of the steam engine, their relations individually to the problem, and the conditions imposed on each by reason of physical conditions beyond our immediate control. The entire cycle of the working substance in the steam engine includes the boiler, feed-water heater and condenser, as well as the steam cylinder, and this entire experience or cycle must be kept in mind in any study of the conditions for improved economy.

In considering the cycle of the steam engine it is most convenient to start with some standard or ideal and then to study the various possibilities of improvement under two heads—first, those which have reference to the improvement or lifting of the ideal, and, second, those which have reference to the closer realization of the ideal, whatever it may be. Thus we may have a series of ideal cycles or sets of conditions for which the values of the efficiency may be 18, 20, 22, 24 per cent. It is obviously of importance to understand clearly the steps which shall enable us to improve this ideal from the lower to the higher values. Again, if we succeed in a final realization of only 70 per cent. of our ideal, the actual values will be from 12.6 to 16.8 per cent., while if by improvement in the conditions the measure of realization could be lifted to 80 or 90 per cent., the final values would be correspondingly improved. For convenience we may call the first of these efficiencies the ideal or cycle efficiency, and the second the process efficiency. As the final value will be the product of these as practical factors, it is clear that it may be improved in either of two ways—by raising the ideal and keeping the process efficiency the same, or at least preventing a decrease of such amount as to offset the increase; or otherwise by raising the process efficiency while holding the ideal at a fixed value; or still otherwise by some combination of those which shall insure a net increase in the product of the two. In order to clearly grasp the distinction between these two factors of the final efficiency, the first or ideal efficiency must be carefully defined. This may be most conveniently done by defining the cycle to which it is assumed to relate. Any ideal cycle might of course be employed, but the one most commonly accepted by engineers when dealing with the steam engine is the so-called Rankine cycle, which consists of the following items or steps:

First, heating of the water in the boiler from the temperature of the condenser to that of boiling, and then vaporization at this temperature to the condition of dry and saturated steam; transfer to the cylinder of the engine without condensation or change of physical condition, and then expansion under adiabatic conditions down to the pressure and temperature of the condenser. Then condensation at fixed temperature and pressure back to the condition of liquid and transfer to the boiler, thus completing the round. For such a cycle the efficiency may readily be shown to depend on the two limiting temperatures, that of boiling and of condensation, and in general, to increase as the range between these two is increased. With this understanding it follows that the ideal efficiency is determined solely by the upper and lower temperatures of the cycle, while the degree to which we are able actually to realize these values gives the measure of the process efficiency.

From this new point it will then be a simple matter to classify the various items which may enter into the problem of the improvement of steam engine efficiency, and to note the character of their limitations and what degree of improvement may be fairly expected of each.

Thus, the general advance in steam pressure means a continuous lift in the upper temperature and a corresponding improvement in the ideal efficiency. The limitations to improvement in this direction are found in the fact that as the pressure is increased there is an increasing tendency toward heat loss by radiation, and likewise the need of a constantly increasing ratio of expansion for the steam. If the conditions are not met there will be an increasing loss in the process efficiency, and thus in the end a loss in the one which may offset the gain in the other. Mechanical difficulties enter also, and having in view the various limitations in this direction, it does not seem likely that any very considerable further advances can be made in steam engine efficiency by increase in steam pressure alone.

Again, any decrease in the lower temperature, such as a change from non-condensing to condensing, or any improvement in the degree of vacuum means a dropping of the lower limit of the cycle and a corresponding opening out of the temperature range, with a resulting increase in the ideal efficiency. The limitations here are chiefly mechanical, and in a general way the engineer can have as low a vacuum as he cares to pay for, or as low as may be indicated by the Kelvin law for economic problems of this character, and to which reference was recently made in these columns. The recent improvement in vacuum for the operation of the steam turbine shows what may be done in this direction, and a part of the excellent showing made by this form of prime mover is directly traceable to this factor. For the reciprocating engine the influence on the ideal efficiency is no less direct, but due to the influence of cylinder condensation the process efficiency is adversely affected, and in this fact is found the chief limitation to the benefit to be derived from the improvement in vacuum, and the consequent dropping of the lower temperature of the cycle. The possibilities of improvement, so far as the ideal efficiency is concerned, are soon exhausted, for the reason that its value depends simply on the upper and lower temperatures, and the possibilities are therefore limited to such changes as may serve either to lift the upper temperature or depress the lower. On the other hand, the influences which may affect the value of the process efficiency are very numerous, and only the more important can be here noted. In fact, any departure from the simple ideal cycle will have its influence and will operate as a factor to modify the process efficiency.

The most important is perhaps cylinder condensation. This violates the conditions of the ideal cycle by substituting for a charge of dry saturated steam at the end of admission a charge of mixed steam and water. The use of superheated steam, as has been noted recently in these columns, is chiefly beneficial because it tends to reduce this action and thus to improve the process efficiency. The use of multi-stage expansion, as in compound and triple expansion engines, tends also in the same direction, and were it not for this fact there would be no object in splitting the operation of expansion up into a series of stages and carrying out each stage in a separate cylinder. Again, incomplete expansion plays an important part in the reduction of the process efficiency, and any change which permits of greater expansion ratio and therefore of greater reduction of pressure, under adiabatic expansion alone, is of direct value with reference to the improvement of the process efficiency. Increased expansion ratio in the reciprocating engine, however, tends to increase the loss due to cylinder condensation, and thus the attempt to improve in one direction is in greater or less measure offset by the tendency to loss in another. It is here that the steam turbine gains again relatively, by the possibility of high expansion ratios without restraint by reason of cylinder condensation. The fact that most of the operations of the actual steam engine are not strictly reversible violates also one of the conditions of the ideal cycle and affects adversely the value of the process efficiency. Likewise all influences which tend to round off the corners of indicator cards violate in one way or another the conditions of the ideal cycle and reduce still further the value of the process efficiency. The various measures which may be taken to improve the cycle of the actual engine with reference to these features operate, therefore, by reason of their influence on the value of the process efficiency, and are limited in effect to the values of the factors which such items may represent in the general resultant value.

The use of steam jackets has reference also to the improvement of the process efficiency by reducing cylinder condensation, but at the expense of the steam used in the jackets, and represents therefore the substitution of one loss for another. The use of feed heaters and economizers has relation to the saving of certain elements of loss in the power plant as a whole, rather than to any modification in the engine cycle itself. To this last statement one important exception may be noted, as found in the use of the step-by-step feed heater. In this case the operation is in effect the fundamental cycle of the engine, carrying its efficiency toward that of the higher or Carnot cycle.

The limitations on the improvement of the various items which may enter into the determination of the process efficiency are physical and mechanical in character, and the improvement due to any given item is naturally limited by the value of the factor which such item may represent in the general value.

These remarks are intended to be suggestive rather than comprehensive, and to call to the attention of engineers the value of an orderly study of all phenomena with which they are concerned, with its analysis and classification with reference to some central or organizing principle. Such orderly study will go far to avoid pitfalls and to show the natural limitations and possibilities of the various items which enter into the problem as a whole.

Railway Reconstruction.

Nothing shows the enormous difference between the conditions of modern railway operation and those existing when the railways of this country were built more markedly than the extraordinary amount of railway reconstruction completed within the past half dozen years, and that now in progress. The pressure of present conditions makes it almost impossible to realize the circumstances attending the opening of nearly all the early railways. Many of the latter, if not by far the greater number, were built chiefly to accommodate passenger traffic under the supposition that it would largely outvalue in receipts the carrying of freight. In view of the uncertain outcome of the early railway projects and the imperative necessity of completing the construction with the least possible expenditure of money, grades and curvature were naturally not regarded as very serious elements in the problem of economic transportation. Far higher maximum grades and sharper curvature than any that would now be considered at all were adopted without hesitation as being consistent with the best principles of good railway business. These early lines doubtless served their purpose, with a high degree of efficiency from the point of view of the business which could then be reasonably anticipated, but with the later development, especially of freight transportation, there has been necessitated a large amount of railway reconstruction in order to haul the heavy freight trains absolutely necessary for modern economic railway business.

In the consideration of these reductions of grades and curves, regarded as permissible by the original constructors, it is interesting to observe the good railway engineering evidenced by the great majority of the original railway locations. While some fundamental errors of location may be found, as a whole it must be admitted that the older railroad locating engineers of the country showed judgment combined with a comprehensive and careful appreciation of the essential principles of the great work before them which reflect unusual credit upon their engineering capacities. Indeed, it is well known that the greatest civil engineering talent available was for many years during the early history of the engineering works of the United States devoted to the location and construction of many railways now forming parts of the great trunk lines of transportation which have been so indispensable in creating the prosperity of the country.

Prominent among these instances of modern railway reconstruction are two works of extraordinary magnitude, one of them being the new low-grade freight line of the Erie Railroad connecting Gaynard, near Port Jervis, and Highland Mills, on the Newburgh branch, near Newburgh Junction, a distance of about forty miles, fully described in this issue of The Engineering Record, the other being a similar low-grade cut-off on the Pennsylvania Railroad for a part of the distance between Harrisburg and Philadelphia, described in The Engineering Record of December 16 and 23, 1905, the latter involving extraordinarily heavy grading work.

The Erie Railroad has in its later history reversed the direction of the bulk of its traffic. In its earlier days its west-bound traffic overbalanced its east-bound, but now the east-bound predominates, and withal it has become a great freight carrier. The sharp curves and relatively heavy grades have long handicapped its capacity, and the remedy of reconstruction which has been found so necessary in other systems must be applied for its relief. In this case practically the whole of the cut-off is on a new location necessitating a tunnel a little more than a mile in length. Although the Newburgh branch aids in the adoption of this new construction, the latter would undoubtedly have to be undertaken in any event. In these days of enormous trunk line traffic with its heavy locomotives and great train loads, within wide limits it would matter little what the improvement would cost which would add over forty per cent. to train capacity with the locomotives now being operated; such an improvement would have to be made. This improved freight line results in a maximum grade of 0.2 per cent., against the east-bound traffic, and a maximum of 0.6 per cent., against the west-bound. There still remains on the unimproved portion of the main line a grade of 0.6 per cent. to be overcome by the east-bound traffic, but that is in the vicinity of Port Jervis, where pushers may be used without material disadvantage. This is shown by the fact that 80 loaded car trains may now be hauled where 55 cars was the maximum limit.

The Pennsylvania improvement, to which allusion has already been made, is so constructed as to leave a maximum grade of 0.3 per cent. to be overcome by the traffic. These reductions of grade, which as they already existed seemed relatively small, illustrate in a most forcible manner the exacting requirements of modern freight transportation by rail. The costs of transportation constitute a material and sometimes large element in the cost of many classes of manufactured goods, not only at the factory, but also at the market where the goods are sold. In the present active competition in business part only of a freight charge may make the difference between competitive prices. It is of the utmost importance, therefore, that transporting agencies should avail themselves of every possible means of reducing freight charges. This means the reduction of grades as one of the important elements of the problem. If a given locomotive and train crew can haul 80 cars instead of 55 the net result is a large increase in the amount of freight handled with a small increase only in cost of train service and operation. Again, there are many cases in which the reduced cost of transportation following such an improvement in grades as that described for either the Erie or the Pennsylvania Railroad would be sufficient to turn large amounts of traffic from a competitor, over the improved line. These features of railway transportation make clear at once why it is profitable for railway companies to expend such great sums of money to reduce grades by the seemingly small amounts of fractions of one per cent.

River Pollution in North Carolina.

The latest judicial decision by a court of final jurisdiction on the subject of river pollution by sewerage comes from North Carolina, where the Supreme Court has issued an injunction ordering the Eno Cotton Mills to employ some method of sewage disposal approved by the State Board of Health for the treatment of its mill and domestic sewage. The case is an interesting one, as showing the general trend of opinion, and particularly because it affirms the constitutionality of the following act passed by the General Assembly last year: "No person or municipality shall flow or discharge sewage into any drain, brook, creek or river from which the public drinking water supply is taken, unless the same shall have been passed through some well-known system of sewage purification approved by the State Board of Health; and the continual flow and discharge of such sewage may be enjoined upon application by any person." If the method of sewage disposal by dilution were regarded judicially as a method of purification, in accordance with the views of some engineers, then this act simply places the whole subject of sewage disposal under the control of the Board of Health; the Supreme Court has not taken this broad view, however, and accordingly North Carolina seems destined to become the happy hunting ground of the horde of agents of patented systems of sewage disposal.

The facts in this case, recently settled by the Supreme Court, 54, S. E. Rep. 453, are as follows: The Durham Water Co. draws most of its supply from the Nancy Rhodes Branch of the Eno River, but during the summer this supply is supplemented by water taken directly from the river. This river intake is 17 miles below the property of the Eno Cotton Mills, where about 300 operatives are employed. The mill sewage and that from the village where the operatives' homes are situated is discharged more or less directly into the river, and the owners of the mill property stated they would continue this practice unless legally prevented. Their reason for taking this stand was that the degree of dilution of the sewage was very great and the nature of the river's course from the mills to the waterworks intake was such that riparian self-purification could be safely relied on to free the water from all chemical or bacterial dangers before it was drawn off for the use of the people of Durham. In making this contention the company simply expressed the opinion generally held by engineers, that disposal by dilution is permissible where the river conditions insure the self-purification of the streams before their waters are used for domestic supply.

The Supreme Court does not express any opinion whether disposal by dilution is a method of purification, but practically forbids its practice on the ground that "the defilement of the water is an injury which is forbidden by the Legislature for perfectly good and sufficient reasons." The court rules that the General Assembly has the power to pass such legislation as "a precautionary measure which is clearly within the police power of the State and to be adopted when deemed necessary to secure the public health." If the measure is needlessly harsh or unduly limits the methods which it is reasonable to employ in disposing of sewage, then relief must be sought by the General Assembly rather than the courts, according to this decision. The effect of this ruling, therefore, is to make illegal the discharge of any quantity of any kind of raw sewage into a North Carolina river. It is a harsh and unreasonable measure, overlooking the most generally satisfactory method of disposal in an endeavor to secure an impracticable and unnecessary condition of purity in the streams of the State. A great deal of commendation is due to the Court, however, for the elaborate detail of its opinion and for the suggestions it has made as to the proper steps to be taken in securing the modification of the law. The Legislature was probably led astray by some of the misleading assertions of sewage disposal cranks, just as the literature of patent medicines has indirectly shortened many lives.

Notes and Comments.

THE STRENGTH OF A GRINDSTONE appears from recent tests to vary widely with the degree of its wetness or dryness, stones that are dry showing tensile strengths of from 146 to 186 lb. per square inch, but after soaking over night breaking under stresses of 80 to 116 lb. per square inch.

MOTOR VEHICLES FOR COMMERCIAL PURPOSES are said to be more used in London than in any other city in the world. There are now 560 motor omnibuses in operation in that city and several hundred more will soon be added. Over 2,500 horses have been displaced by the machines that are already in service.

A MASONRY DAM that will impound 1,250,000,000 gal. of water has recently been completed in connection with the water-works system of Swansea, England. The dam has a total length of 1,250 ft., a maximum height above foundations of 144 ft. and a width at the base of 75.5 ft. The reservoir site that is developed is 1,000 ft. above sea level.

SEVERAL CAST-IRON COLUMNS, each 27 ft. long, 27 in. in diameter at the bottom and 24 in. in diameter at the top, were recently cast in the foundry of the Hansell-Elcock Co., in Chicago. These columns weigh 16,180 lb each and are to be used as stack supports for one of the blast furnaces at the South Chicago plant of the Illinois Steel Co.

STEAM RAISING FROM GAS ENGINE EXHAUST has been practiced at Kilmarnock, England, where the hot exhaust gases from a number of gas engines driving dynamos are passed through boilers with successful results. Tests recently made indicate that 2½ lb. of steam at 40-lb. pressure are evaporated for each horse-power delivered from the dynamos driven by the gas engines.

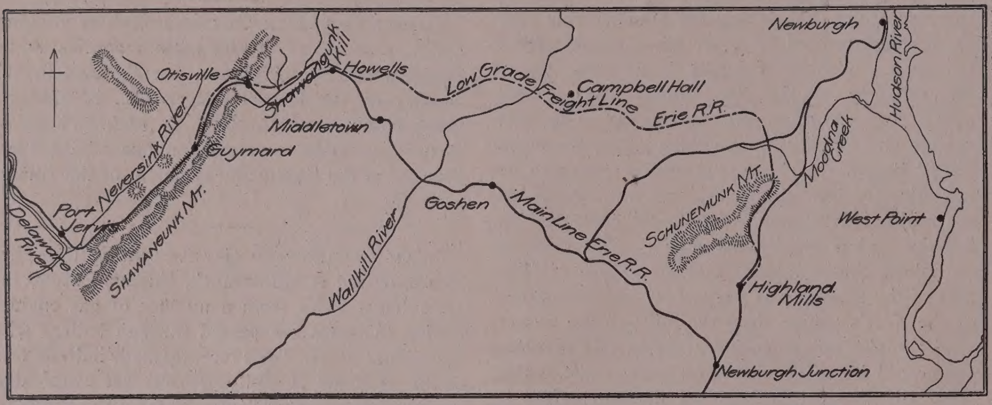
A VERY HEAVY LOCOMOTIVE of the Mallet articulated compound type has recently been placed in service by the Great Northern Ry. It weighs 355,000 lb., of which 316,000 lb. is carried on the driving wheels, the forward engine having a pilot truck and the rear engine a trailing truck. The locomotive is capable of exerting a tractive effort of 71,000 lb. when working compound.

A SYSTEM OF REFUSE COLLECTION is to be put in operation in connection with the tramway system in Dublin, Ireland, within the next few weeks. The refuse is to be burned in a new destructor plant located some distance from the central portion of the city. According to the Surveyor, during the day only enough refuse will be hauled to this plant from districts adjacent to it to keep it in full operation. The remainder of the refuse will be carted to a tramway depot and discharged into large tramway dump cars; during the night these dump cars will be hauled by electric locomotives to the destructor works. Each locomotive will handle a train of dump wagons containing from 70 to 80 tons of refuse, so that in a single journey the refuse not carted during the day may be taken direct to the destructor works. One tramway depot will be used for refuse storage at first, but it is intended to equip other depots later. The various depots will be used not only for storing refuse but also for storing street sweepings, which will also be placed in tramway dump cars during the day, and hauled in these cars by electric locomotives to waste land at night. The destructor plant contains two 4-grate regenerative back-fed Meldrum destructors, having a guaranteed capacity of 120 tons per 24 hr., which supply heat to two Babcock & Wilcox boilers, operating at 200-lb. pressure. The method of collection that is to be followed in the operation of this system of refuse disposal is quite similar to the one which has been successfully employed on a very wide scale for several years by the American Railway Traffic Co., of Brooklyn, N. Y. This organization is a subsidiary company of the corporation controlling the street railway lines in Brooklyn and has a contract with the city for disposing of the ashes and refuse, except garbage, collected by the street cleaning department of the city. This journal also understands that a similar system of refuse collection has been adopted in Frankfort-on-Main, in Germany.

THE NEW LOW-GRADE FREIGHT LINE OF THE ERIE R. R.

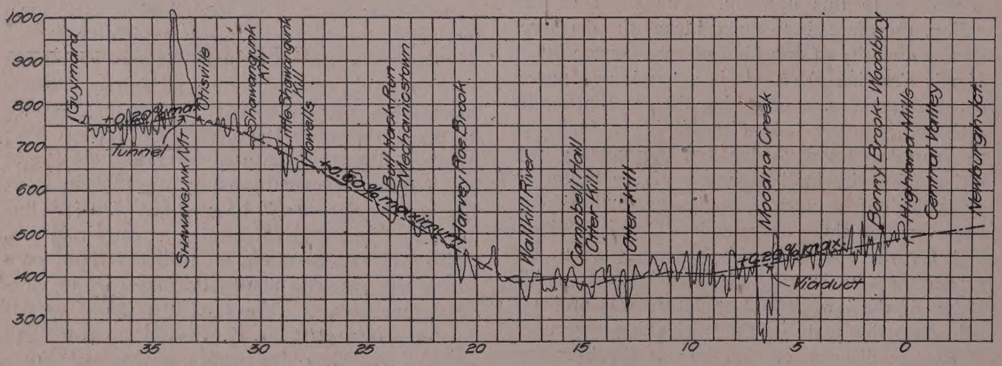
A Heavy Piece of Railroad Construction in Southeastern New York.

A new low-grade double-track cut-off, 40 miles long, is being built in Southeastern New York by the Erie R. R. in connection with the extensive reconstruction and betterment-of-way work that is being carried on along the entire main line of that railroad from Jersey City to Chicago. The cut-off will extend from Guymard to Highland Mills, N. Y., two stations on the New York division of the Erie R. R., which division extends from Port Jervis, N. Y., to Jersey City, N. J., a distance of 89 miles. This division occupies practically the original alignment of that portion of the Erie R. R. as it was completed in 1859, although many betterments of grade and alignment, including the double-tracking of the division and the complete replacement of structures, have been carried out since that time. When the original railroad was located and for many years afterward the balance of traffic was westbound, so that the grades on the old track were not only made at first with this as a controlling feature, but were so maintained for a considerable period. The balance of traffic is now, and has been for a long time, eastbound. The volume of traffic has also greatly increased, especially in recent years, until with the existing trackage facilities and grades it is handled with no small amount of difficulty.



Map of the New Low-Grade Frieght Line of the Erie R. R.

The eastbound grades on the existing tracks of the New York division have a maximum of 0.9 per cent., while the westbound grades have a maximum of 0.6 per cent., and the maximum curvature is 6 deg. Moreover, the country through which the first 40 miles of this division out of Port Jervis is built is very hilly and contains two ranges of mountains, nearly at right angles to the general direction followed by the line, so that a number of long, heavy grades are involved.



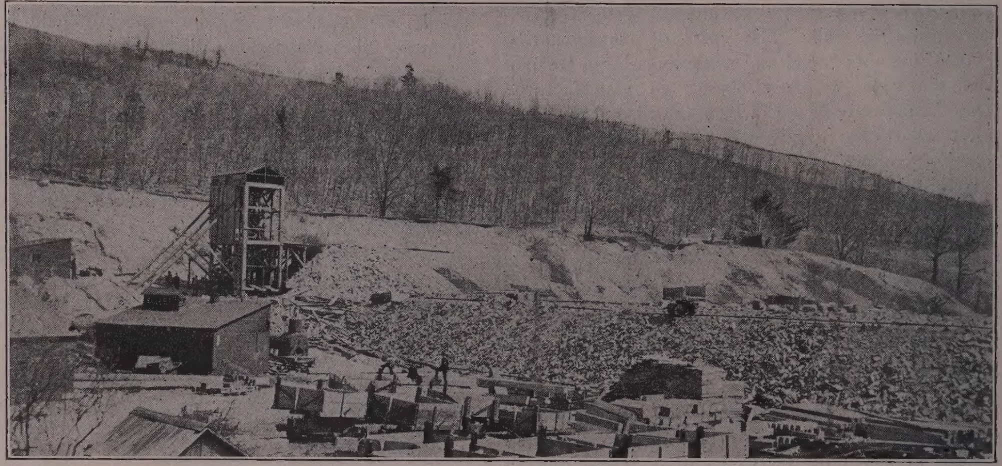
Profile of New Low-Grade Freight Line of Erie R. R.

The new cut-off will have a maximum eastbound grade of 0.2 per cent. and a maximum westbound grade of 0.6 per cent. Its track will be laid with 90-lb. rails and be ballasted with broken stone. Except where unusually high structures are required or where headroom is limited, the bridges and openings for waterways above the capacity of a 30-in. pipe will be of plain concrete.

The two existing tracks of the main line rise on a continuous 0.9 per cent. grade from Port Jervis up to and then along the Shawangunk Mountain through Guymard to Otisville, a distance of 11 miles. A pusher engine is required on all freight trains the length of this entire grade, and even with two engines trains are limited to 55 loaded cars. It is practically impossible to eliminate the first 8 miles of this grade between Port Jervis and Guymard, as the old line parallels the side of the mountain, which is nearly continuous from the northeast to the southwest. As the switching engines from the division yards to Port Jervis are always available for pusher duty, this part of the grade is not held to be such a serious matter as might be considered at first sight.

The two tracks of the cut-off leave the old main line at Guymard, where an under-grade turnout is made in such a manner as to avoid any interference between passenger traffic on the old line and freight traffic on the new. The new line parallels the main line, at varying distances, to the summit of the mountain, being increasingly farther down on the side of the latter. In this distance the line is at right angles to the waterways and well up above the valley. The construction work required consists of heavy bench and thorough cuts through the knolls, with high fills between most of the cuts. The side of the mountain in this distance is nearly all rock, or hardpan, and is taken out with difficulty. The rock is being drilled with Ingersoll-Sergeant steam drills and with Star and Keystone well-drilling outfits. Two steam shovels, a 65-ton Bucyrus and a 60-ton Marion, have been at work along this 4 miles of the line for several months. Trains of 3-yd. dump cars, hauled by Porter locomotives, are used in connection with these shovels to handle the excavated material from the cuts to fills. The amount of material to be moved averages about 100,000 cu. yd. to the mile in these first 4 miles of the work.

The old main line passes through a saddle in the mountain at an elevation of 900 ft. above the sea. The tracks of the cut-off are to be carried through the mountain in a double-track tunnel, 5,300 ft. long. The cut-off swings away from the main line just before entering the west portal of this tunnel until the two lines are about 1,500 ft. apart at the latter. This portal is at the base of a sheer hillside which rises 350 ft. above it, and from it to the east portal the two lines converge until they are about 600 ft. apart.



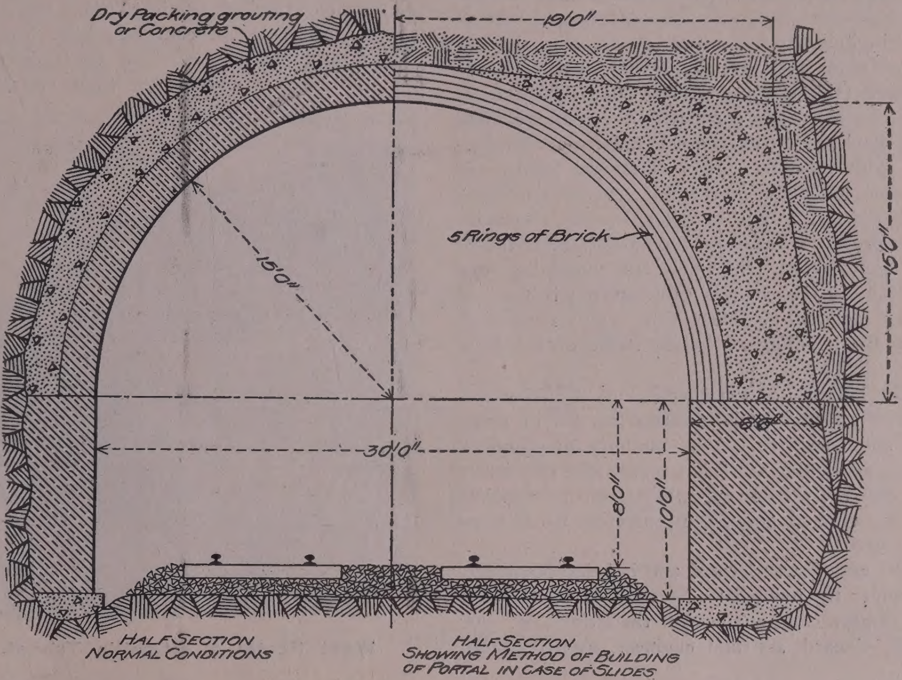
Head House and Muck Piles at Main Shaft of Otisville Tunnel.

The first 3,467 ft. of the tunnel from the west portal is on a 0.15 per cent. ascending grade eastbound, and the first 1,800 ft. from the east portal is on a 0.1 per cent. ascending grade westbound, the two grades being connected by a vertical curve. The accompanying cross-section of the tunnel shows its general dimensions and the method of lining it. The sidewalls of the tunnel will be lined with concrete to the springing line of the arch. The arch will be lined with five rings of hard burned brick laid in cement mortar.

Owing to the limited time between the letting of the contract for driving the tunnel and the date when the new line is to be opened for traffic, the tunnel is being driven from four headings, one from each of the portals, and two from a main shaft 2,600 ft. from the east portal. A top heading roughly the shape of the tunnel arch, and approximately 8 ft. high and 15 ft. wide at the base, is being taken out first. The heading leading west from the main shaft and the one leading in from the west portal are within 100 ft. of each other; the heading leading east from the main shaft and the one leading in from the east portal are about 600 ft. apart. The average rate of progress in each heading, allowing for all delays, is 40 ft. per week, a day and a night shift being employed. It is expected the headings will be completed at a rate at least as rapid as that that has already been maintained, and that the tunnel headings will be entirely finished by Oct. 10, next.

The shaft near the center of the tunnel from which the two headings are being driven is 10x20 ft. in the clear in cross-section and 101 ft. deep. It is equipped with a double hoisting cage operated by a 52-in. drum Lidgerwood hoisting engine, by which all of the material removed from the two headings, driven in opposite directions from its base, is brought to the surface. A difficulty over land titles at the east portal necessitated the sinking of a shaft 50 ft. deep at that point, from which the heading at that end of the tunnel has been driven. The heading in from the west portal has been driven in the usual manner.

The tunnel headings, except for a short distance at the east portal, have thus far encountered a tough sandstone rock that is locally known as Hudson River shale, with an occasional streak of very hard sandstone. This rock or shale is quite distinctly stratified, but the strata are continuous. West from the main shaft the strata are inclined at an angle of about 45 deg. with the horizontal, and no difficulty is experienced in taking out the west portal heading and the heading west from the main shaft without timbering. East of the main shaft the strata are nearly horizontal, so the rock does not stand well when a heading is driven through it. For this reason nearly all of the heading leading east from the main shaft, and all of the east portal heading have been heavily lined with temporary timbering. An open cut, containing 110,000 cu. yd. of material in 700 ft., is now being made as an entrance to the east portal, although the material removed from the tunnel heading at the end is still being taken out through the shaft. This cut is largely pure sand, which extends into the side of the hill at the heading about 100 ft. before the rock is encountered. For this distance the heading is immediately above the rock and through a quicksand formation, so that it had to be closely timbered with 12x12-in. timbers with hay packed in behind the timbering to fill the cracks.


Dry Packing grouting or Concrete
19'0''
15'0''
5 Rings of Brick
15'0''
30'0''
6'0''
8'0''
10'0''
HALF SECTION NORMAL CONDITIONS
HALF SECTION SHOWING METHOD OF BUILDING OF PORTAL IN CASE OF SLIDES

Cross Sections of Otisville Tunnel.

Steam Shovel at Work in a Heavy Cut Through Glacial Drift.

The tools and machinery used in driving the tunnel headings are operated on compressed air supplied by a central power plant located about 500 ft. from the mouth of the main shaft. This plant contains three 160-h.p. Ingersoll-Sergeant compressors, with a capacity of 807 cu. ft. of free air a minute each when supplying air at 100-lb. pressure. These compressors are operated by steam supplied by an 80-h.p. and four 60-h.p. boilers. Pipe lines leading from the power plant to each of the tunnel headings supply air to Ingersoll-Sergeant rock drills in the headings, with practically no loss in pressure, the maximum line of supply being approximately 3,500 ft., and the pressure at the drills 75 to 80 lb. per square inch. Another compressor of the same size as those already installed and two more 60-h.p. boilers are being installed, as the intention is to take the bench of the tunnel out with two steam shovels, operating on compressed air, and the present power-plant equipment is not sufficient to supply the increased demands.

East of the summit of the mountain the main line drops away on a 0.6 per cent. maximum grade and swings off to the north. The cut-off for 5 miles from the tunnel to Howell's, is ½ to 2 miles from the main line. At Howell's the four tracks of the two lines are parallel for about a half a mile, and then the cut-off is entirely independent of the main line in the remainder of its length.

The grading work between the tunnel and a mile beyond Howell's is not unusually heavy, and most of the cuts that have to be made are through sandy soil or pure sand. About 1½ miles east of Howell's a cut containing 300,000 cu. yd. in a mile of length, and including an undergrade crossing of the New York, Ontario & Western R. R., has to be taken out. A mile and a half beyond this crossing is a cut containing 345,000 cu. yd. in 1,800 ft. Following this last heavy cut, the work is comparatively light to the crossing of the Harvey Road Brook, where a 200,000 cu. yd. fill in 1,000 ft. is required over a 20-ft. concrete arch, with a 146,500 cu. yd. fill just beyond. The grading continues to be heavy, averaging over 100,000 cu. yd. to the mile, mostly in shale and hardpan, from this creek crossing to an overhead crossing of the New York, Ontario & Western R. R. near Campbell Hall. A crossing of the Walkill River just west of this overhead railroad crossing involves a plain concrete bridge structure comprising two 40-ft. and three 60-ft. arches.

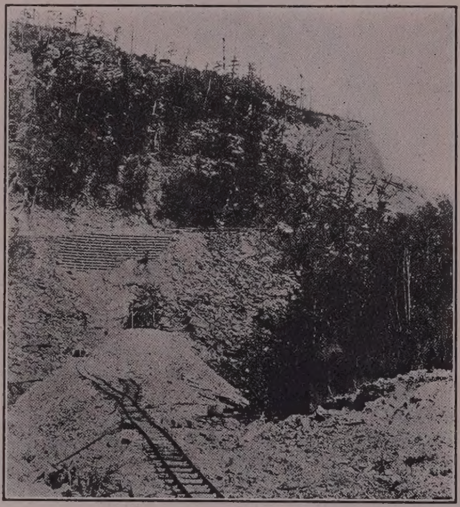
East of Campbell Hall for 9 miles the grading required averages about 140,000 cu. yd. of rock, shale and hardpan grading to the mile. At the end of this portion of the work Moodna Creek is to be crossed on a steel viaduct 3,000 ft. long and with a maximum height of 190 ft. This viaduct is to be built on concrete piers, half of which have been completed. The contract for the fabrication of the steel of the viaduct has been awarded to the McClintock-Marshall Co., of Pittsburg, who will commence the delivery of steel within the next two or three weeks. The erection of the viaduct, which will be carried on by the regular forces of the bridge department of the Erie R. R., will be started as soon as the steel begins to arrive.

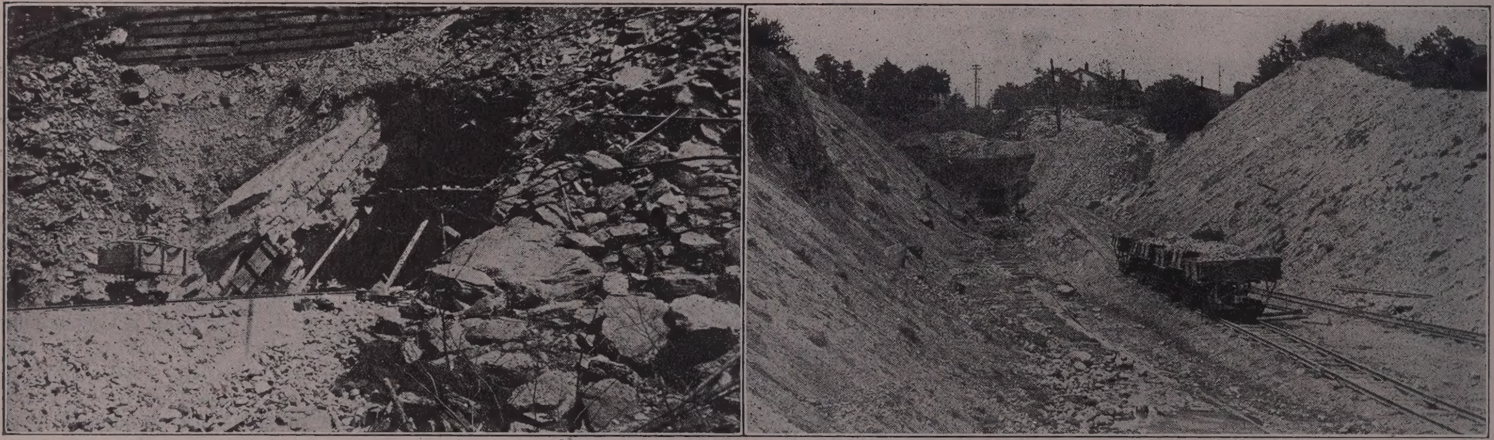
Just beyond this viaduct the line skirts around the base of the Schunemunk Mountains, involving some heavy side-hill rock excavation. A short distance from this mountain the cut-off joins the Newburg Short Cut branch of the Erie R. R., about 5 miles from Newburg Junction, where that branch and the main line come together.

Although the cut-off proper ends at Highland Mills, the grades on the Newburg Short Cut branch as far as Newburg Junction will be changed to conform with those of the cut-off. Two new tracks exclusively for freight service will be built from Newburg Junction to the terminal yards just east of the tunnel through the Bergen Hill, back of Jersey City. When these improvements are completed, the same engines that haul 55-car trains eastbound from Port Jervis, with assistant engines at several points, will be able to handle 80-car trains without a break and without a pusher after leaving Guymard. The proposed relief of the double-track tunnel through Bergen Hill by a cut containing four tracks, and the changes contemplated in the terminal facilities at Jersey City, will further simplify the handling of freight traffic on the New York division.

The building of the 40 miles of new line will require approximately 4,000,000 cu. yd. of grading and 90,000 cu. yd. of masonry to complete. The construction work has progressed sufficiently far that the present expectations are to complete the cut-off and place it in operation by November, 1907.

The cut-off was located and is being constructed under the immediate direction of Mr. Francis Lee Stuart, chief engineer of the Erie R. R. Mr. C. K. Conard, assistant engineer, was in charge of the location work and is now supervising the construction work in the field. The contracts for the construction have been awarded as follows: Guymard to Howell's, including the tunnel at Otisville, Bennett & Talbot, Greensburg, Pa.; Howell's to Walkill River crossing, F. H. Clement & Co., Philadelphia, Pa.; Walkill River crossing to Otter Kill creek, Lathrope, Shea & Henwood, Scranton, Pa.; Otter Kill Creek crossing to Moodna Creek viaduct, Ferguson Contracting Co., of New York; Moodna Creek viaduct to Woodbury, John F. Shields, of New York; Woodbury to Newburg Junction, Sundstrom & Stratton, Middletown, N. Y.


West Portal of Otisville Tunnel.


Inclined Rock Strata at West Portal; Heavy Sand Cut Approach to East Portal, Otisville Tunnel.

The Cunard Turbine steamship, Lusitania, recently launched, is the largest vessel that the world has yet seen, having a length over all of 785 ft., a breadth of 88 ft. and depth of 60½ ft. The motive power embraces six turbines, four for ahead motion and two for backing, the speed capacity of the four ahead turbines of 6,000 i.h.p. being 25 knots. The vessel has a cargo capacity of 1,500 tons and carries 2,350 passengers.

Steel Falsework Used in the Erection of the Quebec Bridge.

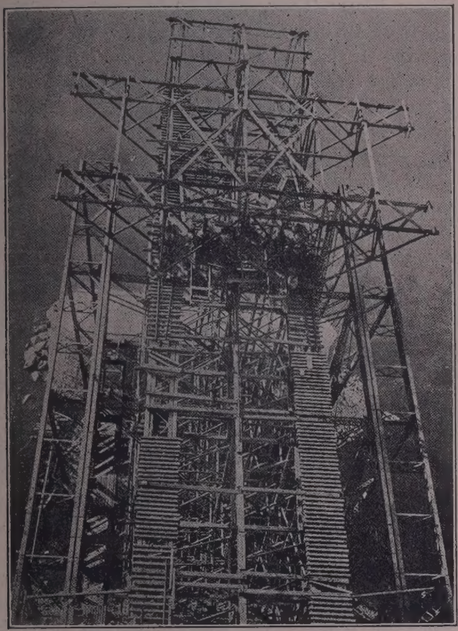
The erection of the 500-ft. South anchor arm of the 2,800-ft. double-track railroad and highway bridge across the St. Lawrence River at Quebec has been finished, and that part of the superstructure is now completed except for some of the field riveting, which will not be done until a portion of the work on the 1,800-ft. channel span has reached a finished stage and conditions of a permanent character have been developed in these trusses. The 500-ft. span has two trusses, 98 ft. deep at the shore end 315 ft. deep at the river end, in vertical planes 67 ft. apart, and weighs about 12,500,000 lb. Both lower and upper chords are curved to form parabolic segments, and the lower chord is now supported on steel falsework about 150 ft. and 54 ft. above low water level at the shore and river ends, respectively. When the bridge is completed there will be under full live and wind load a maximum vertical pressure of about 28,000 tons on the river pier, while at the anchorage there may be a maximum upward reaction of 7,000 tons. During the erection of the bridge many of the stresses in the truss members which may eventually receive these extreme amounts were reversed and the total weight of the structure was carried directly by the piers and by the falsework between them.

The falsework, exclusive of a wooden structure, designed simply to temporarily carry the material tracks, consists essentially of two parallel lines of steel viaducts, one line concentric with each truss. It has a total weight of about 1,200 tons, and a height of from 127 to 160 ft. All field connections were made with turned bolts, and it was designed to facilitate its removal from the south side of the river and its re-erection for the other anchor arm on the north side of the river. The general description and partial diagrams of this falsework were published in The Engineering Record, March 4, 1905; since then the shop details have become available, and from them the following description of the most important features has been prepared.

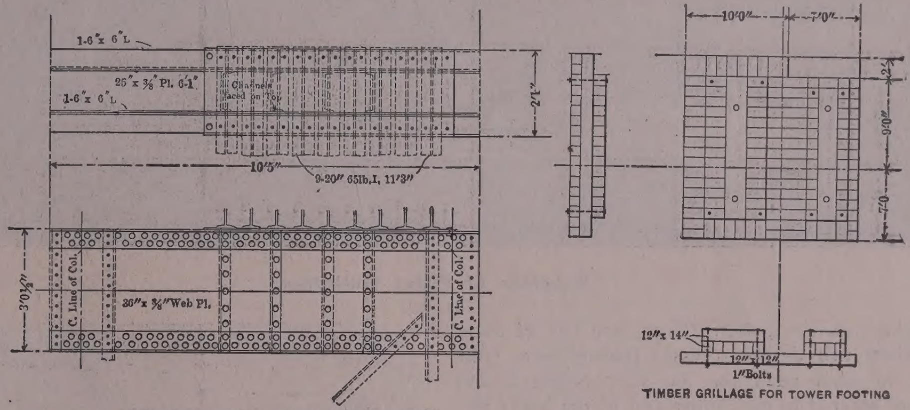
The falsework consists of two parallel rows of rectangular 9x9-ft. steel towers, 50 ft. apart, with their centers coincident with the panel points of the trusses. The towers are braced together longitudinally and transversely, so that two pairs of single towers make one large tower separated from the next by an open panel, except at the river end, where six towers are placed together making the large tower double. The falsework is equal to standard railroad viaduct work in point of careful design, strength, standard construction, quality of material, rigid inspection and workmanship. Each tower is built with four vertical posts, two of which, nearest the river, are extended from about 10 to 80 ft. higher than the others to carry on each side of the bridge a 12-ft. gauge traveler track, with its center line 18 ft. clear of the truss center. These extended posts are braced to the main towers with outside inclined posts forming a reversed batter and intersecting the tower at about the middle of the short posts.

The posts have rectangular cross-sections made with pairs of 12-in. or 15-in. channels with their flanges turned in and latticed. All posts are made in three sections spliced with milled butt joints and single outside cover plates, four in all, field-bolted to gusset plates and also bolted to the webs and flanges to afford connections for the diagonal 3x2½-in. angles that lattice the four columns together to form one primary tower. The main horizontal members connecting the primary towers in transverse and longitudinal planes to make the main towers, are riveted struts made with plates and angles; the corresponding diagonal members are 3-in. and 5-in. eye-bars. The lower ends of the posts are faced, and their feet engage double pedestals which distribute the loads over the footings.

The pedestals are of two kinds, one of which is shown in the accompanying illustration, and is virtually a pair of plate girders projecting 2½ ft. beyond the center lines of the posts and having the lower flanges united by a continuous base plate. At each end the webs are connected by a pair of shop-riveted channels with open holes in their webs to receive the bolted connections to the post webs which engage them. Connection plates are riveted to the webs outside to receive the eye-bars, forming the diagonal members of the towers. The other type of pedestals substantially consists of two ordinary pedestals receiving the posts as above described and connected together only by the flange angles which are continuous across the face of the tower and correspond with the lower flange angles in the pedestal illustrated. The web plates and base plates connected to them, are not as in the former cases continuous, but have short lengths suited for the single posts.



Top of Steel and Wooden Falsework, July, 11, 1905.

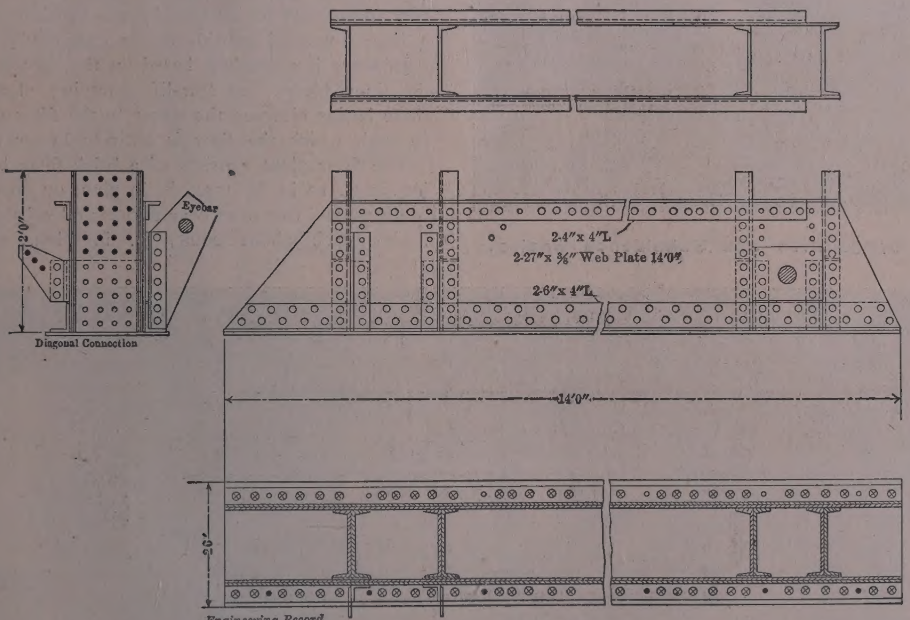


GIRDER SUPPORTING GRILLAGE AT TOP OF TOWER

TIMBER GRILLAGE FOR TOWER FOOTING

Engineering Record

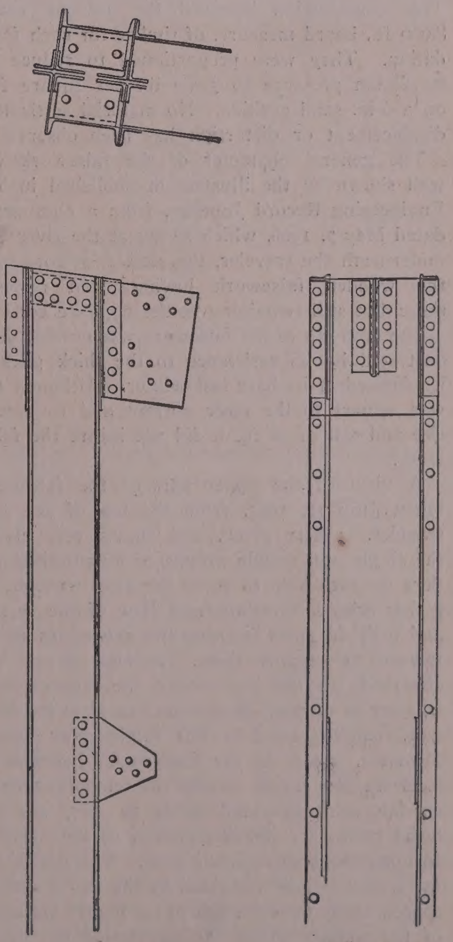
Details of Steel Falsework.



Engineering Record

TOWER PEDESTAL

Details of Steel Falsework.



Engineering Record

Top of Inclined Post.

The top sections of the short posts, which support the trusses, have their flanges bolted between the webs of twin transverse girders, four at each primary tower. Each of these girders is 3 ft. deep, with a ⅜-in. web plate and a single 6x6-in. outside angle for each flange. The webs are connected and reinforced by four vertical 12-in. channels shop-riveted to both, so that the pair are handled together as a single rigid piece. The top flange angles are connected by a 25x⅜-in. cover plate about 6 ft. long, which serves as a base plate to receive a grillage of nine 20-in., 65-lb. I-beams, about 11 ft. long, on which the camber blocks are set.

The upper ends of the long posts carrying the traveler track are faced to a level corresponding to the grade of the track, and are provided with horizontal inside and outside flange angles as shown in the diagram, to receive the stringer connection. The webs of the post channels are also stiffened with pairs of vertical angles, back to back, to provide for the heavy shear developed by the traveler load. The tops of the inclined posts are of similar but lighter construction.

The tops of the extended vertical posts receive two lines of plate-girder stringers, 58 in. deep, temporarily borrowed from the permanent floor system of the cantilever arm. These are seated on the post cap and are connected together by horizontal bolts and washers through the end vertical web-stiffener angles. Clearance is provided between the ends of the stringers for ¼-in. vertical plates, bolted between the angles on the tops of the posts and projecting above the latter to engage the stringer connection bolts and tie the stringers to the tops of the falsework towers, thus enabling them to resist the upward stress from live and wind loads in the traveler. A single line of stringers is similarly connected to the tops of the inclined tower posts 12 ft. on centers from the inner pair of stringers. The lines of stringers are connected by light latticed struts in vertical transverse planes. Fifteen panels of the stringers were used and were taken up from the rear and shifted to the front as the traveler advanced.

The steel and wooden falseworks were erected simultaneously by an overhead wooden traveler of special construction erected by jin poles and derricks on the permanent track of the approach span. It consisted essentially of a 46x62-ft. tower, 25 ft. high, running on three single lines of rails 23 ft. apart. It was provided with a forward overhang of 41 ft. and two transverse overhangs of 30 ft. on each side, thus increasing the over-all dimensions to about 100 ft. in length and 116 ft. in width. The transverse overhangs were each made with a pair of trusses 11 ft. apart, extending continuously across the full width of the traveler and provided, like the forward overhang, with jigger beams from which the hoisting tackles were suspended. This traveler was equipped with two standard double-drum, four-spool Lidgerwood hoisting engines, which, being used before the erection plant was completely installed, were operated by ordinary steam engines instead of the electric motor which later superseded all other motive power on the work.

Each primary tower is seated on a single continuous footing composed of wooden grillages receiving the two long pedestals for the transverse pairs of posts at every tower. Shallow excavations were made in the rock and earth and were leveled up to give a surface about 18 ft. square on which was laid a tier of 12x12-in. longitudinal timbers close together. Near each end of these timbers two tiers of crossed timbers were built up to form seats for the steel pedestals and were secured to each other and to the lower tier by eight vertical bolts, one at each end of each end timber in the upper tier, thus fixing the latter as guides to hold the intermediate timbers. This construction involved the use of nearly 8,000 ft., board measure, of timber for each foundation. They were proportioned to reduce the maximum pressure to 3,000 lb. per square foot on a 6-in. sand cushion. No material settlement, displacement or distortion has been observed.

The general character of the falsework was well shown by the illustration published in The Engineering Record June 23, from a photograph dated May 7, 1906, which shows at the river end, underneath the traveler, the steel falsework only, the wooden falsework having been removed there, but still remaining at the opposite end.

The strength of the falsework was notably demonstrated by its resistance to the thick piles of ice formed at its base last winter. Although this was subject to the river current and to a tidal rise and fall of 12 ft., it did not injure the falsework.

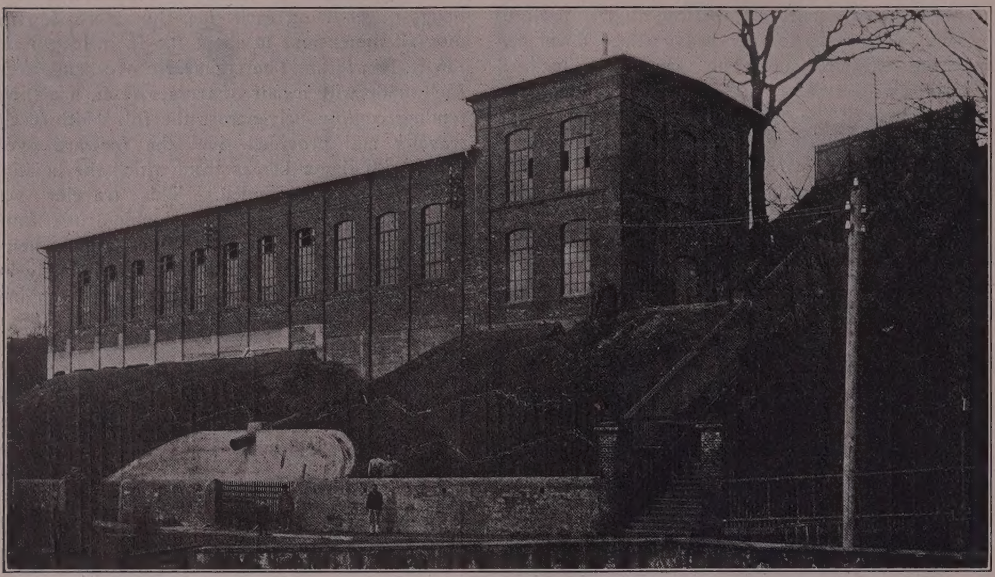
A view of the upper part of the falsework, taken July 11, 1905, from the top of the steel traveler, is here given, and shows very clearly the single and double groups of longitudinal girders on each side to carry the steel traveler, together with a foreshortened view of the vertical and inclined posts forming the extensions of the towers to support them. It also shows very effectively in the background the large wooden traveler of unusual design used to erect the falsework and described in The Engineering Record, March 4, 1905. In the foreground between the steel traveler tracks is seen the temporary wooden falsework provided solely to carry the material tracks for the distribution of the members forming the south anchor span. The position of the tracks is here indicated by the ties which are spaced ready to receive them for nearly the length of the tracks. After the completion of the anchor span the floor system in the assembled structure sufficed to provide support for the two material tracks on which the members for the remainder of the bridge up to the center of the 1,800-ft. span will be delivered, thus releasing the temporary tracks and permitting the removal of the falsework which carried them.

Mr. E. A. Hoare is the chief engineer, and Mr. Theodore Cooper, consulting engineer, of the Quebec Bridge Co. The contractor for the steel work and erection is the Phoenix Bridge Co.; Mr. David Reeves, president; Mr. John Sterling Deans, chief engineer; Mr. A. B. Milliken, superintendent of erection, and Mr. G. A. Tretter, assistant to superintendent of erection.

A Rapid Sand Filter Plant in Germany.

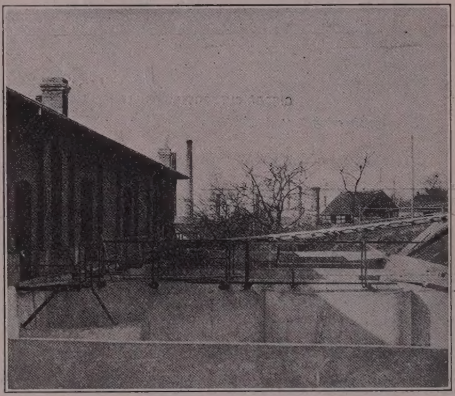
By Edmund B. Weston.

An American system, or rapid sand filtration plant has recently been completed at the large dyeing and bleaching works of Mr. Louis Hirsch in Gera, Germany. Gera, the capital of the German principality of Reuss-Schleiz, is on the White Elster River, 42 miles by railroad east by south of Weimar, and has a population of about 40,000. It has broad and regular streets and its older buildings include a castle and a fine town hall. The city contains many woolen and cotton mills, dyeing and print works, machinery and leather factories and several breweries.



Exterior of Filter Building.

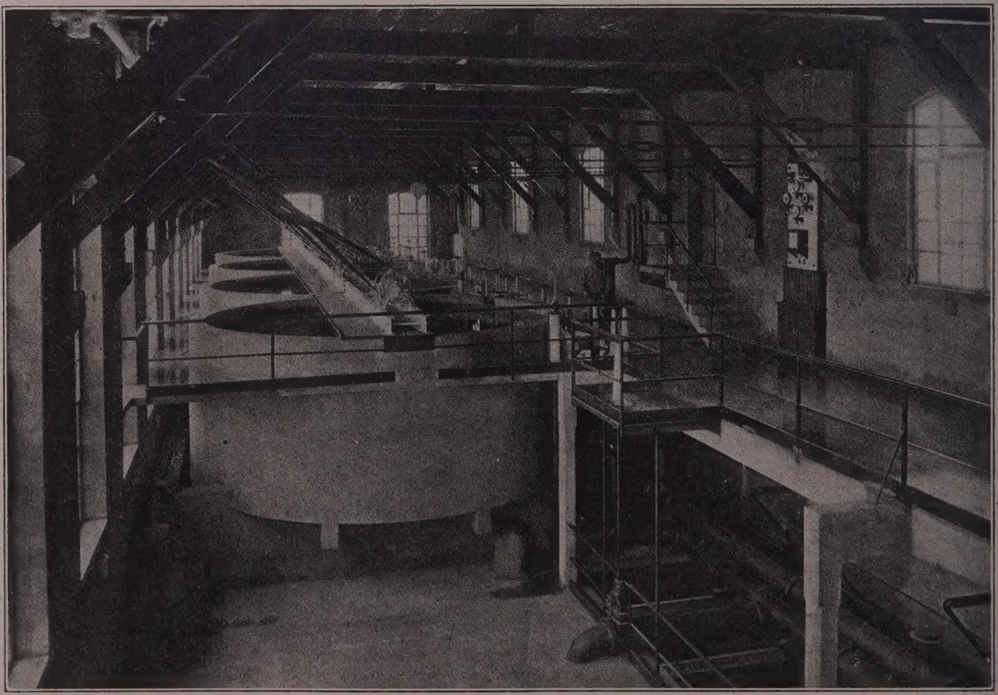
Mr. Hirsch, while in this country on a visit to the Louisiana Purchase Exposition at St. Louis, Mo., in 1904, called on the writer for advice in regard to the purification of the water supply of his works at Gera. After inspecting filter plants in this country he decided to install an American system of filtration plant to be designed in accordance with the recommendations of the writer, as consulting engineer for the Jewell Export Filter Co. He accordingly made a contract with that company to furnish all of the material for the filters and auxiliaries in the filter building, with the exception of the reinforced-concrete tanks of the filters and a centrifugal pump and two electric motors required for the filter washing equipment.



Coagulation and Subsidence Basins.

The raw water that is treated in the plant is taken from a canal which derives its supply from the White Elster River. It flows from this canal by gravity into two preliminary subsidence basins built of masonry in the west bank of the canal about 325 ft. from the filter plant. The two preliminary basins are of a size to allow about 3 hours' natural subsidence or coagulation and subsidence if necessary, based on the capacity of the four filters. A low-lift pumping plant at these basins elevates the water to the filter plant, through which the flow is entirely by gravity.

The filter plant consists of a brick filter building 32 ft. 10 in. by 153.5 ft. in plan, on concrete footings, and two open coagulation and subsidence basins each about 29x63 ft. in plan, which adjoin the filter house and are built of reinforced concrete. The general arrangement of the filter plant proper is shown in the accompanying reproduction of the preliminary plan of the filter



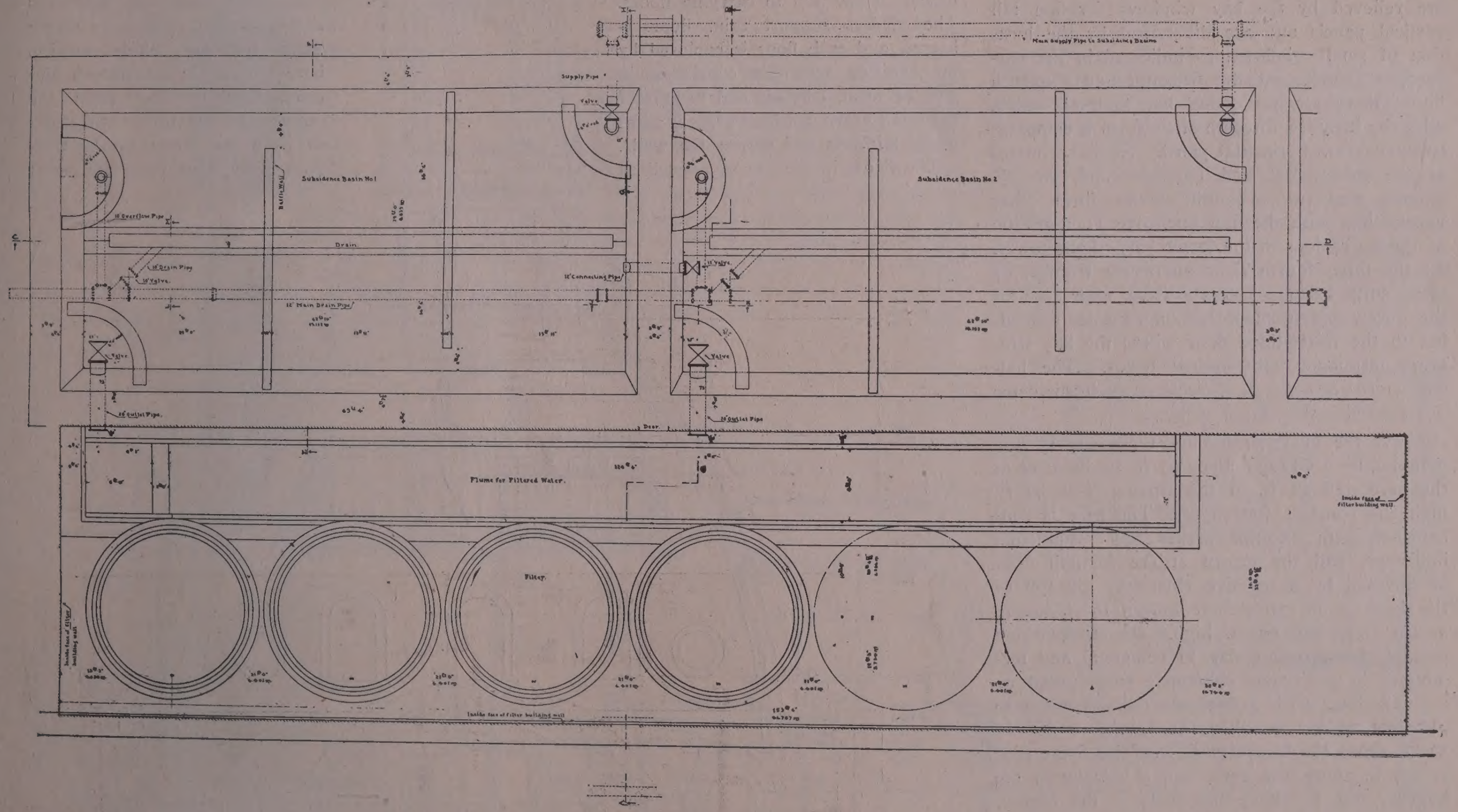
Interior of Filter Building.

building and two coagulation and subsidence basins. The filter building contains four reinforced-concrete filters 17 ft. in diameter, each of the Jewell gravity type with sufficient space for two additional filters of the same capacity. The total capacity of the four filters is 3,042,000 U. S. gal. per 24 hr. The coagulation and subsidence basins are of such size as to allow about two hours' continuous coagulation and subsidence, based on the capacity of the four filters. These basins are arranged so a third basin may be added in the future.

The filtered water passes from each filter to a flume built below the floor of the building and thence to storage tanks.

The centrifugal pump and electric motors required for washing the filters are placed in one end of the building. The sand agitating apparatus used in washing the filters is belt-driven from a line shaft. The flume into which the filters discharge has a low wall or overflow weir across it at one end which retains sufficient water in the flume to wash one filter.

In the portion of the building where it is intended to put in two more filters in the future, a sludge receiver is built under the floor into which the dirty water first flows when the filters are being washed, in order that the heavier material may settle before the water passes into the drain which empties into the city sewers. Arrangements are also made so that the sludge from the coagulation and subsidence basins can be flushed into the sludge receiver. The sludge is removed from the sludge receiver through an iron pipe leading from one side of the building, shown in the exterior view of the building, and is discharged into carts which carry it away.



General Plan of Filter Plant, Showing Piping Connections.

Sulphate of alumina is used as a coagulant. The coagulant feed is located in the higher portion of the building, shown in the exterior view of the building, which allows the coagulant to flow by gravity to the coagulation and subsidence basins, and to the preliminary subsidence basins if it is thought desirable to use coagulant in the preliminary basins.

The turbidity in the raw water sometimes reaches 1,000 parts per million. The guarantees made by the Jewell Export Filter Co. regarding the efficiency of the filter plant were to the effect: That with a turbidity of 750 parts per million in the raw water, the effluent from the filters should be bright and clear and so free from matter in suspension that with a Jackson candle turbidimeter no turbidity could be measured in a tube 1 meter in length; also that the filtered water should not contain any more alumina than the raw water.

The filter plant was placed in operation in January, 1906, and has given excellent satisfaction. The rate of filtration has been 146,000,000 U. S. gal. per acre per 24 hr.

The writer, as consulting engineer of the Jewell Export Filter Co., prepared the detail plans of the filters and their auxiliaries and the preliminary plans for the coagulation and subsidence basins and filter building. Mr. E. B. Young, chief engineer for Mr. Hirsch, prepared the other plans required. Mr. E. A. Gieseler, general manager of the Jewell Export Filter Co. for Germany, with Mr. W. L. Lawton, Jr., as superintendent of construction, has supervision of the work done under the Jewell Export Filter Co.'s portion of the contract.

Flat Hoop Roof Tanks for Sprinkler Systems require careful examination of their hoops before the approach of the winter season to determine whether they are rusting from the back. If found corroded so as to materially weaken them, the tank should be strengthened by placing new hoops of round iron between the flat hoops. Examination may be made by striking the hoops with a pointed hammer at intervals of a few inches, in order to find the thin places. A hoop may be in perfect condition at one point and nearly rusted off within six inches of that point. Flat hoops rust more rapidly where they do not fit tightly against the staves, because dirt collects there and holds the dampness. Particular attention should be given to tanks located on roofs and covered with corrugated iron as some building laws require.

A 40-Story Building in New York City.

The adjacent Singer and Bourne Buildings at the northwest corner of Liberty St. and Broadway, New York, are steel frame office buildings 10 and 14 stories in height, which together occupy an area of about 10,000 sq. ft. with fronts of about 172 ft. and 58 ft. on Liberty St. and Broadway, respectively. Both buildings are owned by The Singer Co., which has recently acquired several adjacent lots on both streets, thus controlling a considerable area of land in the congested down-town district where the demand for offices is great and rentals are high. It was therefore decided to make additions to the old buildings so that with their extensions they should virtually form a single building covering the full 24,000 sq. ft. of available site. Both exterior and interior will be treated as a single building with free communication throughout all stories and a single equipment for the service and operation. The lower portions of the adjacent buildings will be extended to the same height, uniform with the main roof of the additions, which will have 14 stories above and one story below the street.

At the fourteenth story there will rise above the roof of the Singer extension, a large tower with the highest point of its roof over 612 ft. above the curb. This tower, which will be by far the tallest structure ever built for commercial occupation, and, next to the Eiffel tower, the tallest now in existence, will nominally have forty stories above the surface of the street, although in reality there will be forty-two accessible floors including a mezzanine floor devoted to storage and mechanical apparatus, which is not included in the formal enumeration. The dimensions of the tower would justify it in being considered as a regular office building rather than a tower, except that the great height gives it an appearance of slenderness which is comparative rather than actual. It is rectangular in plan with faces 63 ft. long, one of which is parallel with the Broadway building line and about 30 ft. back from it so that the tower rises from near the middle of the roof of the extension, giving the latter the appearance of a base about 200 ft. high.

Wide bay windows projecting 3 ft. beyond each of the exterior walls of the tower are treated as architectural features and enlarge the floor area to 3,737 sq. ft., thus providing for a number of good size rooms devoted to commercial purposes on each side of the elevator shaft which occupies the center of the tower, an arrangement which together with the general location of the offices, corridors, stairways, light courts, and so on, is indicated by the accompanying second floor plan, typical of the arrangement from the third to the thirteenth stories inclusive. Above the fourteenth story there are no rooms, except those in the tower, the location of which is indicated on this plan, although it is not separated from the main building below the fourteenth story roof.

Great care has been taken in the architectural treatment of the tower, which has been studied to make it harmonious with the building and to secure the greatest beauty and impressiveness combined with dignity. The faces of the shaft are relieved by the bay windows forming tall vertical panels and are diversified by the location of small windows, as indicated in the perspective sketch. At the fifteenth and sixteenth floors there are projecting belt courses which, with the included fifteenth story form a comparatively narrow horizontal panel. Similar courses at the twenty-first and twenty-second, twenty-seventh and twenty-eighth stories form other panels that, with the first one, give a suggestion of three divisions in the lower part of the tower. At the thirty-fourth floor an ornate trompe, or terra cotta balcony projects from each face of the tower, and is supported on consoles extending to the thirty-third floor where the bay windows terminate with arched heads. The balconies are segments of a circle 40 ft. in diameter intersected by the faces of the tower.

Above the thirty-sixth floor the tower is surmounted by a circular dome 63 ft. in diameter at the base and 28 ft. at the crown; it is 50 ft. high and contains four floors. The base is conbellished with exterior arches and ornamental bull's-eye, and the crown at the fortieth floor is enclosed by a massive cheneau. On top of the dome is an ornamental lantern 16 ft. square at the base and 60 ft. high. Its cross-section changes from rectangular to octagonal and terminates in a circular colonnade surmounted by a small dome with a flag pole rising from it to a height of 652 ft. above the curb, or 666 ft. 10 in. above the basement floor. The dome roof is 550 ft. above the curb, and a balcony in the lantern, 564 ft. above the curb, is the highest point in the tower accessible to the public. The highest office story is at the thirty-eighth floor, being at an elevation of 524 ft. The main balcony at the thirty-fourth floor is 468 ft. high.

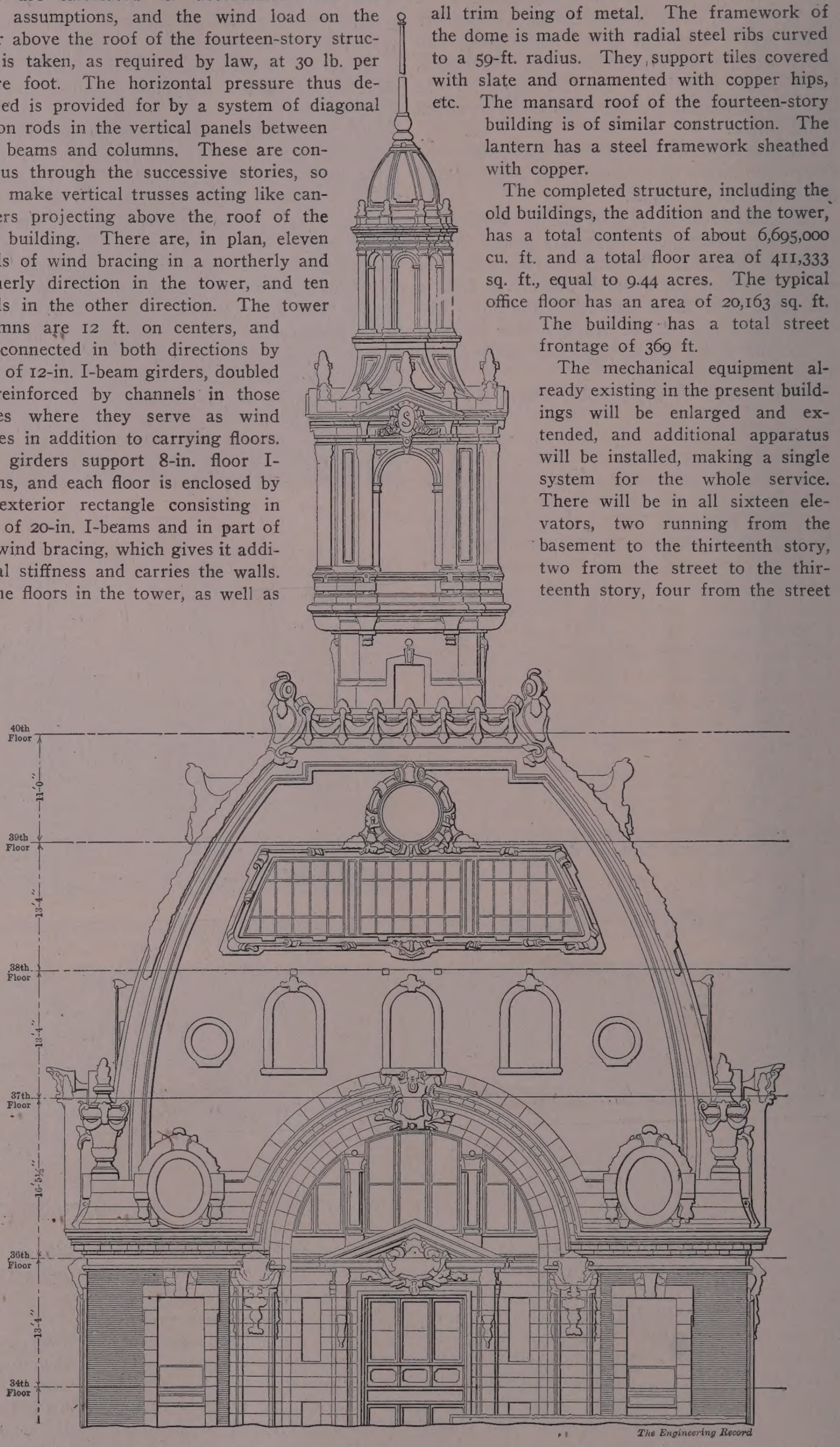
The construction of the additions is comparatively simple, and corresponds to standard practice for steel cage buildings, the walls being supported from the columns at every story. The columns all have closed rectangular cross-sections made with channels and cover plates, and the beams and girders are arranged with comparatively short spans and are made in most cases with rolled I-beams or channels. The 52x100-ft. addition to the Bourne Building has grillage foundations of the Hennibique type of reinforced concrete seated on the sand at ground water level, about 25 ft. below the curb, and uniformly loaded to a maximum pressure of about 5,000 lb. per square foot. The 75x115-ft. addition to the Singer Building has the foundations which support its fourteen-story columns and those of the forty-story tower carried to rock at a depth of about 70 ft. by the pneumatic caisson process, the loads on these piers being limited by the building law to 15 tons per square foot pressure on the concrete. The combined caisson area is about 2,784 square feet. The floor loads in the main building and in the tower are calculated in accordance with the usual assumptions, and the wind load on the tower above the roof of the fourteen-story structure is taken, as required by law, at 30 lb. per square foot. The horizontal pressure thus developed is provided for by a system of diagonal tension rods in the vertical panels between floor beams and columns. These are continuous through the successive stories, so as to make vertical trusses acting like cantilevers projecting above the roof of the main building. There are, in plan, eleven panels of wind bracing in a northerly and southerly direction in the tower, and ten panels in the other direction. The tower columns are 12 ft. on centers, and are connected in both directions by lines of 12-in. I-beam girders, doubled or reinforced by channels in those places where they serve as wind braces in addition to carrying floors. The girders support 8-in. floor I-beams, and each floor is enclosed by an exterior rectangle consisting in part of 20-in. I-beams and in part of the wind bracing, which gives it additional stiffness and carries the walls.

The floors in the tower, as well as in the other portions of the new structure, are to be built of flat hollow tile arches and to have cement finish. Some of the partitions are made with 2 in. of lath and plaster on an angle-iron framework, others are made with 4-in. hollow terra-cotta blocks. The exterior walls are of brick trimmed with stone up to the main roof and with terra-cotta in the tower above it. The walls of the tower are of brick, 12 in. thick at the top, and are battered on the outside to a thickness of 38 in. at the base. All of the structural steelwork not protected by the floor, walls and partitions is fireproofed with hollow tile. The building is intended to be absolutely fireproof, and no wood is used in its construction or finish, all trim being of metal. The framework of the dome is made with radial steel ribs curved to a 59-ft. radius. They support tiles covered with slate and ornamented with copper hips, etc. The mansard roof of the fourteen-story building is of similar construction. The lantern has a steel framework sheathed with copper.

The completed structure, including the old buildings, the addition and the tower, has a total contents of about 6,695,000 cu. ft. and a total floor area of 411,333 sq. ft., equal to 9.44 acres. The typical office floor has an area of 20,163 sq. ft. The building has a total street frontage of 369 ft.

The mechanical equipment already existing in the present buildings will be enlarged and extended, and additional apparatus will be installed, making a single system for the whole service. There will be in all sixteen elevators, two running from the basement to the thirteenth story, two from the street to the thirteenth story, four from the street to the thirty-fourth story, and one from the thirty-fourth to the thirty-eighth story, besides four in the Bourne Building and three now in operation in the Singer Building. They will be operated up to a maximum speed of 600 ft. per minute.

The building will be heated by the direct-indirect radiator system with 95,000 sq. ft. of heating surface. It will be ventilated by an exhaust system providing for a circulation of

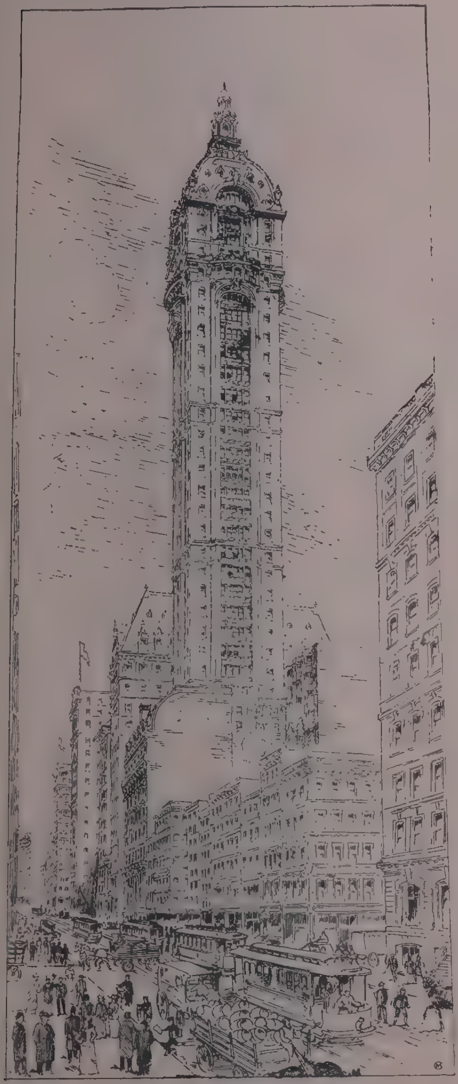


Architectural Details of Upper Stories and Dome.

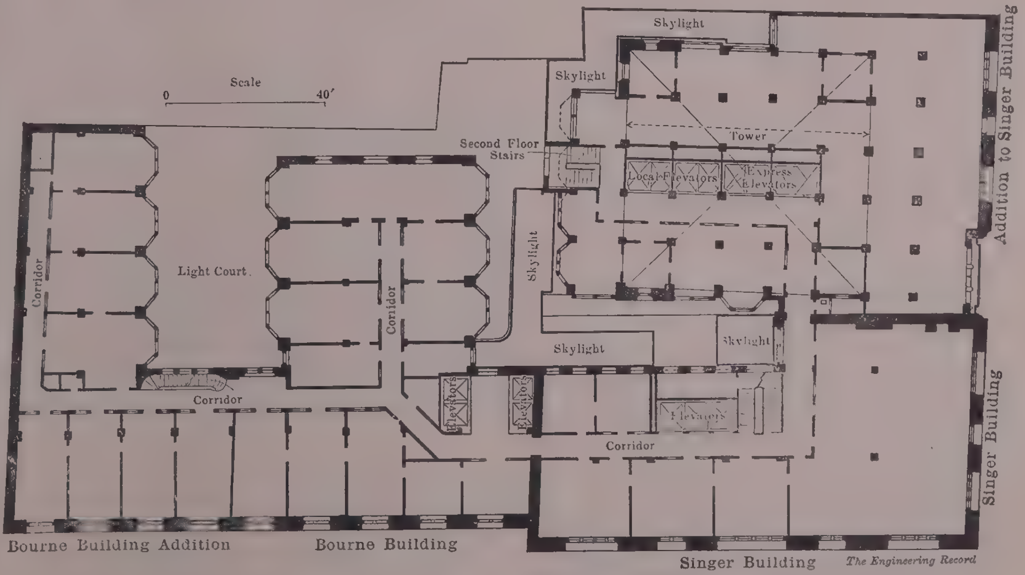
13,287,000 cu. ft. of air per hour. The water system will be elaborate and comprehensive, furnishing abundant supply under suitable heads for all purposes throughout the building and tower. The fire system will have the usual standpipes with hose reels on every floor and siamese connections for fire engines at the sidewalk. Constant pressure will be maintained by the fire pumps, and a storage of 20,000 gal. will be reserved for a gravity fire supply from the elevated tanks. The domestic water service in the building will be divided into four different vertical groups, reducing the gravity pressure. It will be operated by a 5,000-gal. tank on the roof of the Bourne Building, three tanks with a combined capacity of 6,000 gal. in the thirteenth story of the Singer Building, a 5,000-gal. tank at the twenty-seventh, a 7,000-gal. tank at the thirty-ninth, and a 3,000-gal. tank at the forty-second story of the tower, all of them connected by suitable valves and by-passes. The estimated water consumption is 15,000 gal. per hour, the fire pumps having a capacity of 120,000 gal. per hour. There will be a filter plant with a capacity of 20,000 gal. per hour, and a hot water heating plant with a capacity of 3,000 gal. per hour. An ice water plant will also be established, with circulation to drinking fountains in every story and a capacity of 420 gal. an hour. A compressor plant will develop air pressure of 80 lb. per square inch, which will be distributed throughout the building and used for cleaning boiler tubes and similar purposes.

The power plant will have a 2,000-h.p. battery of boilers, electric generators of 1,450-kw. capacity, pumps of 225 h.p., ventilating fans of 185 h.p., and a vacuum sweeping plant installation of 70 h.p. The cost of the building, as estimated on the plans filed with the Building Department, is about $1,500,000 for the Singer addition and $300,000 for the Bourne addition.

Mr. Ernest Flagg is the architect, and Mr. O. F. Semsch, of his engineering staff, chief engineer. Messrs. Boller & Hodge are consulting engineers for the structural design. Contracts have already been awarded to The Foundation Co. for the pneumatic caisson work in the substructure of the Singer addition, and for the Bourne addition, to the Hennibique Co., for the foundations; to Milliken Bros. for the structural steel work; to J. T. Brady & Co. for the masonry; to Mr. J. J. Spurr, Newark, for the limestone, and to the Whale Creek Iron Works, for the ornamental ironwork.



Perspective View of Building.



Typical Floor Plan of Combined Building.

The Prevention of the Growth of Algae in Water Supplies.

The prevention of the fouling of reservoirs and conduits of water-works systems by various vegetable growths has attracted general attention on the Continent in Europe as well as in this country and in tropical climates, but in England it is only recently that detailed investigations and experiments to determine the feasibility of the various methods for preventing algæ growths in water supplies have been carried on to any extent. The results of these investigations and experiments were described in a paper presented at the last annual meeting of the Royal Sanitary Institute by Messrs. Samuel Rideal and Ronald Orchard, an abstract of which follows:

The contamination frequently consists of one, or several, of the very numerous algæ, many of which, besides causing the clogging of valves, etc., and an unsightly appearance, are capable of imparting disagreeable odors and tastes. Trials have been made to destroy or inhibit the growth of the plants by the addition of a minute quantity of germicidal substance to the water. Various reagents have been employed in the laboratory to prevent the dense, unsightly growths occurring in the glass outer jackets of Liebig condensers, which we have found to consist largely of desmids and other unicellular algæ allied to protococcus. These are inhibited for a short time by introducing strips of bright metallic copper; solid naphthalene gives better results, retarding all growth for a long period.

On a large scale metallic salts such as those of iron or copper have been used. The employment of the latter in the form of crystallized copper sulphate has met with a fair amount of success, the poisonous copper being subsequently precipitated as a basic salt, the coagulating effect of which often renders the finished water very clear and bright.

In the early experiments in this direction by Dr. G. T. Moore, of the United States Agricultural Department, the quantity of crystallized sulphate required from 1 part per 1,000,000 to 1 per 50,000,000, while some waters did not appear to be amenable to the copper treatment. He found that the worst tastes and odors are most susceptible. In conjunction with Dr. Kellerman he recommends the following dilutions per 1 part of copper sulphate for the destruction of each organism named: Clathrocystis, 8,000,000; cœlospherium, ,000,000; microcystic, 1,000,000; oscillatoriæ 5,000,000. However, Messrs. Rideal and Orchard have found that the growth of a conferva (a variety of spirogyra) was inhibited but by no means entirely destroyed by the addition of 1 part per 1,000,000, in an English lake water. Some forms of algæ appear to flourish especially in calcareous waters, and also in those containing quantities of free CO_2; on the other hand they prevented the growth of conferva and desmids in tap water with this gas.

The time required for the subsequent natural precipitation of the copper varies with different waters from some twenty-four hours to twenty days. A soft South African water recently examined in the laboratory, did not become clear even in the latter time. This is a serious objection, especially when it is remembered that the coagulum rapidly clogs filters. In some instances a fractional treatment would be more economical. However, the cost of material is in any case insignificant; taking copper sulphate at £28 per ton, the amount for treating 1,000,000 imp. gal. of water with 1 part would cost 2s. 6d. The chief outlay is always incurred in labor, storage, and the systematic testing of the product for freedom from copper. In a former paper, in conjunction with Dr. Baines, it was pointed out that the minute amount of copper required to destroy algæ would not be harmful to man. Up to last year the Massachusetts Board had declined to sanction employment of copper salts for drinking waters.

In the addition of the germicide to large reservoirs it must be remembered that the solution will diffuse downwards and horizontally, any upward movement being very slow. At Newport (Mon.) reservoirs were successfully treated by trailing bags of copper sulphate across the surface of the water, the rate of solution being controlled by the thickness of the material enclosing the salt.

Similar experiments at Gloucester water works have been successful in removing the spring growth from the reservoir. Trials by the Massachusetts State Board of Health in 1903 and 1904 with copper sulphate gave conflicting results.

A proprietary article, containing available chlorine, has been advertised for removing the green growth and slime in swimming baths, but we are not aware that any attempt hitherto has been made to employ a solution chlorine or its oxides for the preservation of these growths in potable waters. Their adoption, however, for this purpose is indicated by their recent successful application, in the form of an electrolytic chlorine solution, for the sterilization of effluents, and certainly laboratory experiments, which have been made are very promising. The advantages over the use of a poisonous element, such as copper, are obvious. Even if the treated water was distributed with its full amount of available chlorine it would not be harmful in the high dilution employed, but the removal of the chlorine is rapid and very certain, so that the only permanent addition to the water is a minute quantity of common salt. Possibly the staple perchlorate is formed as a final by-product, but the amount is so infinitesimal that it cannot be detected. The employment of chlorine alone does not in any way clarify turbid water, but there is no added danger of the subsequent clogging of filters. As with copper sulphate the actual cost of material is low, and electrolytic plants are now on the market which require but little attention when once adjusted for a specified output.

In the laboratory experiments already alluded to an electrolytic chlorine solution obtained from the Digby hypochlorite plant has been employed; this solution, besides having the advantage of cheapness, contains but little undecomposed sodium chloride, and consequently the final addition of chloride to the treated water is very small.

In considering the treatment of water with electrolytic chlorine, first of all the immediate chlorine consumed figure must be determined, that is to say, the available chlorine at once taken up by the organic matter of the water, since obviously in order to successfully inhibit growth the addition of the chlorine should be equal to or in excess of this amount, although in one of our experiments an addition of only half the average chlorine immediately consumed (0.17 part per 1,000,000) decidedly retarded growth in tap water.

The value can be approximately calculated from the oxygen consumed figure, but should be determined directly. The available chlorine consumed in five minutes by drinking waters usually falls below 0.5 part per 1,000,000; in two London tap waters it was found to be 0.345 and 0.33 part and with a lake water 1 per 1,000,000.

From experiments made on a large scale at Guildford with tap water purposely infected, it was found that the addition of 0.66 part per 1,000,000 of available chlorine destroyed objectionable bacteria of the coli class in less than one hour, and that the residual available chlorine completely disappeared after some twenty hours' exposure in the large tanks.

In our recent laboratory experiments, quantities of water drawn from the lake in St. James' Park were treated with varying amounts of an electrolytic chlorine solution and of copper sulphate. These, together with untreated samples of the water, were kept under the most favorable conditions for the growth of algæ. Of course the growth in all cases was dependent upon the amount of sunlight from day to day, and the best results were obtained in colorless glass vessels with partial aeration. Green glass, and to a lesser extent great aeration, decidedly retard growth. Periodical examinations were made, and when growth was apparent it was examined under the microscope for identification. After some four to seven days all the untreated controls showed vigorous, green, filamentous growths, starting from the bottom of the vessels, which, after a longer period, permeated the whole volume of the liquid. They then became less definite in character and obviously of a mixed nature, owing to the later development of the numerous other algæ present in the lake water. Microscopical examination revealed that the bulk of the growth in the untreated water at first consisted of two varieties of a conferva—spirogura. Subsequently numerous other algæ, green desmids, and diatoms, especially asterionella, developed. It was found that successful sub-cultures from the lake water experiments could be made into tap water, copious growths being obtained after a week; these were fairly pure owing to the sharp differentiation caused by the available chlorate added in the original lake water experiments, and a further series was made using the tap water so infected.

As already stated, the immediate chlorine consumed figure of the lake water was 1 part per 1,000,000, and the tap water 0.33; briefly the conclusions arrived at from these experiments were:

1. Green growth can be entirely prevented by the use of electrolytic chlorine.

2. The different microscopic plants decidedly require varying amounts of chlorine to inhibit their development, confervæ appearing to be most susceptible to treatment. Available chlorine just in excess of that immediately consumed by the water, although disappearing itself in a few hours, inhibited confervoid growth for some weeks. Desmids were found to be slightly more resistant, and in the experiments required the addition of some 0.5 part per 1,000,000 in excess of that immediately consumed by the water. Diatoms appeared to be still more resistant, and required 1 part per 1,000,000 of chlorine in excess.

3. Animalculæ, like daphnia and cyclops, are not killed by even larger doses of chlorine, and were found actively mobile after a month's treatment with 11 parts per 1,000,000.

4. The addition of 1 part of copper sulphate per 1,000,000 was not successful with lake water, as it did not clarify, and the green growth was only slightly retarded. The effect was not equal to the use of 1.2 parts (0.2 in excess) of chlorine per 1,000,000.

5. Under the microscope a distinct bleaching of the colored algæ was noticed with upwards of 2 points per 1,000,000 of available chlorine; this cannot occur without strong physiological action. An exception to this occurred in one experiment with the lake water, where the desmid, ankistrodesmus, was not bleached by 2.02 parts per 1,000,000 and after some four weeks' inhibition appeared to be starting fresh growth.

An important factor, the chemical condition of the treated water as representing that distributed for consumption, was also dealt with in these experiments. In all cases the added available chlorine completely disappeared, 1 part per 1,000,000, added to tap water, could not be detected after five hours, and even in the maximum addition of 11.2 parts per 1,000,000 to the lake water (which is greatly in excess of that required), no available chlorine remained after a few days' sojourn in a partially-filled glass vessel, loosely plugged with cotton wool. In fact, this rapid decomposition of hypochlorites into chloride and oxygen somewhat militates against their use, as in practice the germicide might be removed too quickly, especially by agitation of the water.

The natural chloride, originally present in the lake water, was found to be somewhat high; 14.71 parts chloride per 100,000. The electrolytic chlorine solution contained 0.2 per cent. available chlorine and 3.17 per cent. sodium chloride (this was employed diluted to one-tenth with distilled water), so that treatment with 2.2 parts per 1,000,000 of chlorine, which was found to preserve the lake water for upwards of a month, required eleven volumes of the electrolytic solution per 1,000 volumes of water. Theoretically, this increases the total chloride of the water from 14.71 to 16.64. The actual amount found in the treated water was 16.73 parts per 100,000.

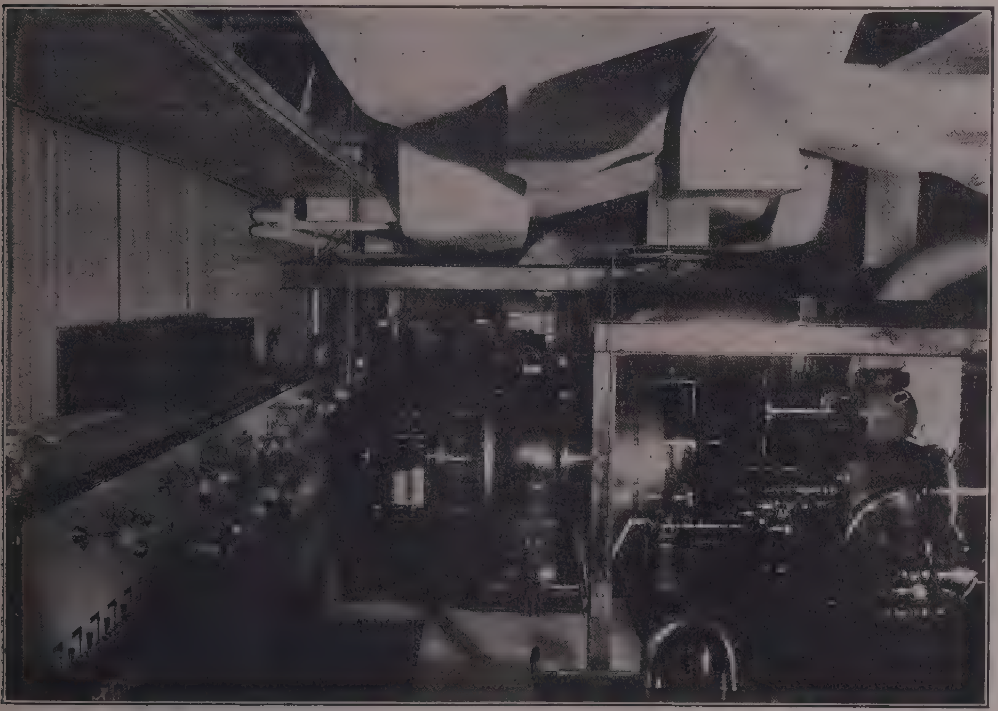
Mr. Read, of Gloucester, in discussing the paper said they had had a great trouble from algæ growing in the bottom of the reservoir wherever light could penetrate, and the growth of this algæ had produced a fishy taste and smell. Ten years ago he consulted with the city analyst, and they decided to try sulphate of iron and spread about a half ton over this growth and killed it. The next year, however, there was a great increase in the growth of the algæ at the bottom of the reservoir, although it had been cleaned out. Last year he communicated with the Board of Agriculture at Washington, and they sent him a lot of literature, the sulphate of copper treatment being mentioned. The experiments made by Mr. Read had to be carried on very cautiously, as there were fishing rights in the reservoir which were retained by the Lord of the Manor. Decision was to try 1 part in 3,000,000. The reservoir contained 30,000,000 imp. gal. of water, so 1 cwt. of sulphate of copper was added to the water. This was in the spring of the year. Mr. Haines, of Newport, tried a similar treatment the year before in which he used three proportions—1 in 5,000,000, 1 in 1,000,000, and 1 in 500,000. The two former proportions acted all right, but the 1 in 500,000 killed all the fish. He crushed the crystals up to something of the consistency of sugar and scattered them over the surface of the water, and within a few hours a fishy smell arose from the surface, and this continued for twenty-four hours. In Mr. Haines' case, he said that a thick scum was thrown up on the surface of the water, but it disappeared in the course of twenty-four hours, and the water clarified. At Gloucester the analyst made tests for copper, and in forty-eight hours no copper could be found by the most delicate tests. As a matter of precaution he did not put the water on the town for a week. Since then no trouble has been experienced with the fishy smell, and Mr. Haines thought that probably one treatment in the year would be all that would be required.

THE WRECKED DRAW SPAN of the Interstate bridge in the harbor at Duluth, Minn., the accident to which was described in The Engineering Record for Aug. 18, last, so effectually blocked the channel leading from the inner harbor that one of the adjoining 800-ton fixed spans was removed from its piers to permit navigation to be reopened pending repairs to the disabled span. As was formerly mentioned, the steamer Troy of the Western Transit Co. collided with the 501-ft. draw span of the bridge at one o'clock on the morning of Aug. 11, with the result that both ends of the span collapsed and fell into the water. The heavy traffic in and out of the inner harbor was thus completely shut off, and as the replacement of the wrecked span will require several months the decision was made to remove one of the fixed spans at the earliest possible moment. Two large scows were, therefore, floated under each end of the fixed span and partially submerged. Timber cribbing was then built upon each of the scows to the floor beams of the bridge. When the cribbing had been completed the water ballast was pumped out of the scows, which, as they rose, lifted the span from its piers. The scows and span were then towed by three tugs to the site of a falsework of piling on which the span will rest pending the completion of the repairs to the disabled draw. A channel, 170 ft. wide with 25 to 30 ft. of water, and with 19 ft. of water over a 230-ft. channel, is now provided. The fixed span was removed by Whitney Bros., traffic being reopened 89 hr. after the accident, while the span was actually moved in a little more than 48 hr.

Power Plant of the Hotel St. Regis, New York.

The power plant equipment of the Hotel St. Regis at Fifth Ave. and 55th St., New York City, is one of the most complete that have been installed in a modern public building of that character. It embraces a 1,000-kw. electrical generating plant, a 1,400-h.-p. boiler plant, a 50-ton refrigerating plant, and an unusually extensive equipment of auxiliary machinery for hotel service purposes. The greatest part of the auxiliary equipment is steam driven for the purpose of supplying exhaust steam at low pressure to the heating, ventilating, hot water and water distilling plants of the building, to which reference was made in detail in an article in The Engineering Record for August 25.

The entire sub-basement of the hotel is given over to the power plant and mechanical equipment, with the exception of a 30x72-ft. space underneath the Fifth Ave. sidewalk which is utilized for kitchen storage purposes. The general arrangement of the mechanical equipment involves, as shown in the accompanying sub-basement plan, a 72x100-ft. engine and pump room in the central portion, a 45x50-ft. boiler room in the northeast corner and a 45x50-ft. fan room at the rear. Underneath the 55th St. sidewalk are arranged a workshop, toilet and locker rooms for the employees, store rooms and, at the front corner, a 15x30-ft. room devoted to filtering equipment for the water supply from the city mains. The space devoted to the actual power plant equipment, 2,250 sq. ft. for the boiler room and 20x90 ft. in plan, or 1,800 sq. ft. for the generating equipment, an installation of 1,000-kw. capacity, is unusually small, yet a convenient and workable arrangement of apparatus has been secured. The elevator machines, which are of the horizontal hydraulic type, were double-decked for economy of space and the ammonia compressors of the refrigerating equipment, as well as other units of apparatus, were installed of a vertical type.



Electrical Generating Equipment in Power Plant.

Boilers and Auxiliaries.—The steam generating equipment of the plant consists of four 360-h.-p. Heine water-tube boilers which are set in three batteries in the boiler room at the rear of the sub-basement. They are arranged in three settings, one containing two units and the other two single boilers each, and a 7-ft. space is provided at the rear and sides for access to piping connections, and cleaning doors. In front of the boilers a 17-ft. firing floor is provided, which is surfaced with checkered cast-iron floor plates and is traversed by an overhead I-beam runway for a trolley hoist to convey coal from the storage bunker under the sidewalk to the boiler room. This runway is a standard 6-in. I-beam suspended from the ceiling and carries a plain, hand-operated trolley with chain hoist; at the entrance to the boiler room the runway is cut and a section fitted with weighing scales for the measurement of coal used. The coal is handled in 500-lb. capacity buckets, which are filled manually in the coal bunker and dumped at any point desired over the firing floor. There is arranged at the rear of the firing floor, a steel-plate fence or enclosure, 2 ft. in height, which serves to confine the coal to the center of the firing floor and keeps a passageway free at the rear for access to numerous piping connections and to doorways leading to different portions of the sub-basement.

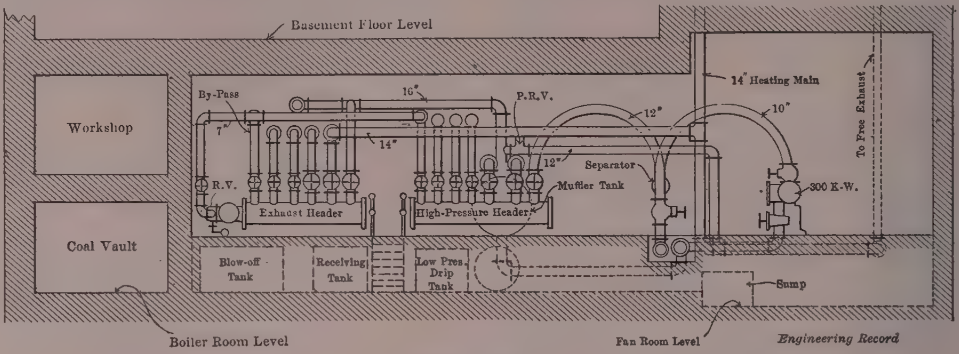
The boilers have each a 48-in. steam drum, 21 ft. long, with the Heine wrought-steel tube headers attached at either end, between which are fitted the tubes. This entire structure is mounted in an inclined setting. The steam drums and headers are built up of 7/16-in. plates, the boilers being designed for a working pressure of 150 lb. per square inch. Each unit has two hundred and three 3½-in. tubes, 18 ft. long, giving a heating surface of 3,500 sq. ft. The boilers are equipped with hand-fired furnaces with effective grate areas of 46 sq. ft. each, the furnaces being fitted with McClave shaking grate bars of the divided cut-off type, 7 ft. in length, with fire-brick lined flame bridges. As an excellent draft is available from a steel stack carried up above the roof line, anthracite coal of the No. 1 buckwheat grade is burned with success. The stack is 60 in. in diameter and is carried up to the roof in a pipe and ventilation shaft, 9x11 ft. in cross-section, to a height of 300 ft. above the grates. The boilers are connected to the stack by a 48x72-in. breeching of No. 10 black iron, heavily covered with asbestos block insulation, with two 18x60-in. connections for each boiler.

The boiler feeding equipment consists of four 7½x5x6-in. duplex steam pumps, which are located in a section of the main machinery portion of the basement adjoining and depressed to the level of the boiler room. These pumps are flexibly connected for service in various combinations, but serve mainly to return the water of condensation from the receiving tanks of the heating systems. Each is fitted with a Kieley automatic pump governor for automatic operation according to the duty required on the delivery line. The feed is delivered through a 45x121-in. Goubert vertical closed feed water heater for preheating, which heater contains 250 sq. ft. of heating surface in 2-in. seamless brass tubing. From here the feed water passes for purification to a Ward combination zinc box and filter, which is composed of eight cast-iron cylinders, 15 in. in diameter by 7½ ft. high, fitted with special cast-zinc bars and filled with animal charcoal; the feed system consists of 3½-in. header with 2-in. branches to each boiler, the delivery from the filter passing through a Worthington hot-water meter. The pumps are supplemented by two No. 6 Nathan injectors which have suction connections to the city water service and deliver through the main header of the feed system.

Each boiler has a 2½-in. blow-off connection from the rear water leg to a 3½-in. blow-off header located at the rear of the settings, which leads to a blow-off tank beneath the floor in one corner of the boiler room. This tank is of ½-in. flange iron, 3½ ft. in diameter by 8 ft. long, and has a 3½-in. vapor pipe connection leading to the 6-in. vapor riser in the smoke stack shaft to the roof. Water is lifted from this blow-off tank up to the sewers in the adjoining street by a 7½x6x10-in. duplex pump with Johnson automatic governors, consisting of a float in the tank which causes the pump to operate continuously as long as the tank is more than half full. The hot blow-off discharge is cooled partially by 80 lineal feet of 3-in. brass piping through which cold water is passed from the street mains to the domestic hot water heaters, thus reclaiming a portion of this waste heat.

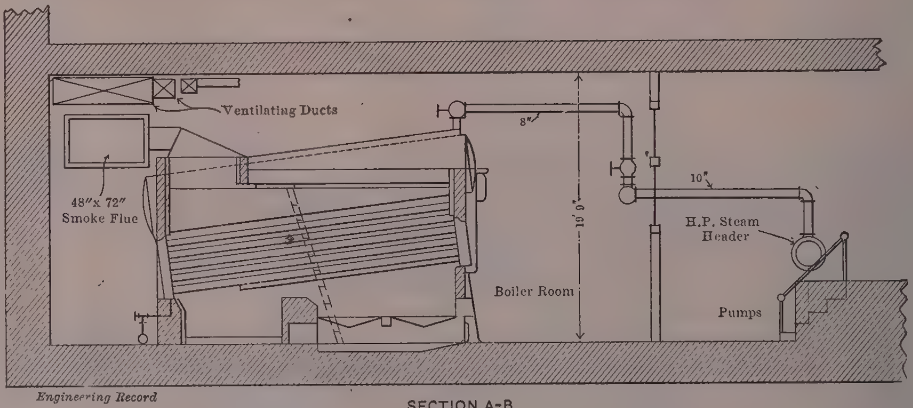
Piping.—The steam piping system of the plant involves an arrangement of distributing headers for both high pressure steam and exhaust, by means of which the piping connections are rendered more than ordinarily convenient for a plant of this magnitude. The main engine and machinery room floor beyond the depressed portion occupied by the boiler feed pump equipment is raised 5 ft. higher than the boiler room floor level, and on the edge of the raised portion of the floor are located the two large pipe headers, one for high pressure steam and the other for exhaust. The former is a 20-in. header and receiver, 13 ft. long, of heavy steel-plate construction and has two 10-in. steam-supply connections from the boilers and five delivery branch connections. It is built of ⅜-in. steel plates, anchored firmly to the floor and has all supply and delivery connections at the top and drip connections only at the bottom. The 10-in. boiler connections each serve two boilers with 8-in. branches to each, there being gate and non-return stop valves in each boiler branch. The delivery connections from the header consist of a 10-in. main which supplies the electrical generating units, a 7-in. connection supplying the refrigeration machinery ,another 7-in. line connected through a pressure-reducing valve to the low-pressure header to supply make-up for the heating system, and two 6-in. connections, one for the pumping machinery and the other for general high-pressure steam service throughout the building.

The exhaust steam header is a special cast-iron manifold fitting, 18 in. in diameter by 11 ft. long, with two supply and four delivery connections. The supply involves a 16-in. connection to the muffler tank of the engine-room exhaust steam system and a 7-in. connection from the high-pressure header through the pressure-reducing valve for supplementing the exhaust steam supply when the latter is insufficient for heating purposes; this pressure-reducing valve is a 7x14-in. Kieley valve which delivers into the rear end of the header and it is by-passed by a 7-in. connection direct to one of the manifold outlets for emergency supply. The delivery connections from the low-pressure header consist of a 14-in. heating main which is carried to the upper floors for the heating stacks of the indirect steam heating equipments, a 10-in. line to the tempering coils in the sub-basement fan room, a 6-in. line to the sub-basement relay heating stacks and a 6-in. delivery to tempering coils of a ventilating system upon the second floor. The exhaust header also has an atmospheric relief connection for freeing it of excess pressure in case the steam is not used as fast as produced; this consists of a 12-in. line leading from the muffler tank through a Kieley noiseless back-pressure valve and up the pipe shaft to the roof line where it is capped with a 12-in. exhaust head. The main exhaust line from the engine delivers to the low-pressure header through a Potter muffler tank, a receiver 54-in. in diameter by 6½ ft. long, with separating screens and coke filter for partial removal of oil; this tank is of ⅜ in. iron plate and contains 24 discs of galvanized-wire ¼-in. mesh screeen. At the outlet from the muffler tank is connected a 16-in. Cochrane grease extractor for the removal of oil from the exhaust, with a drip connection to the low-pressure drip tank.



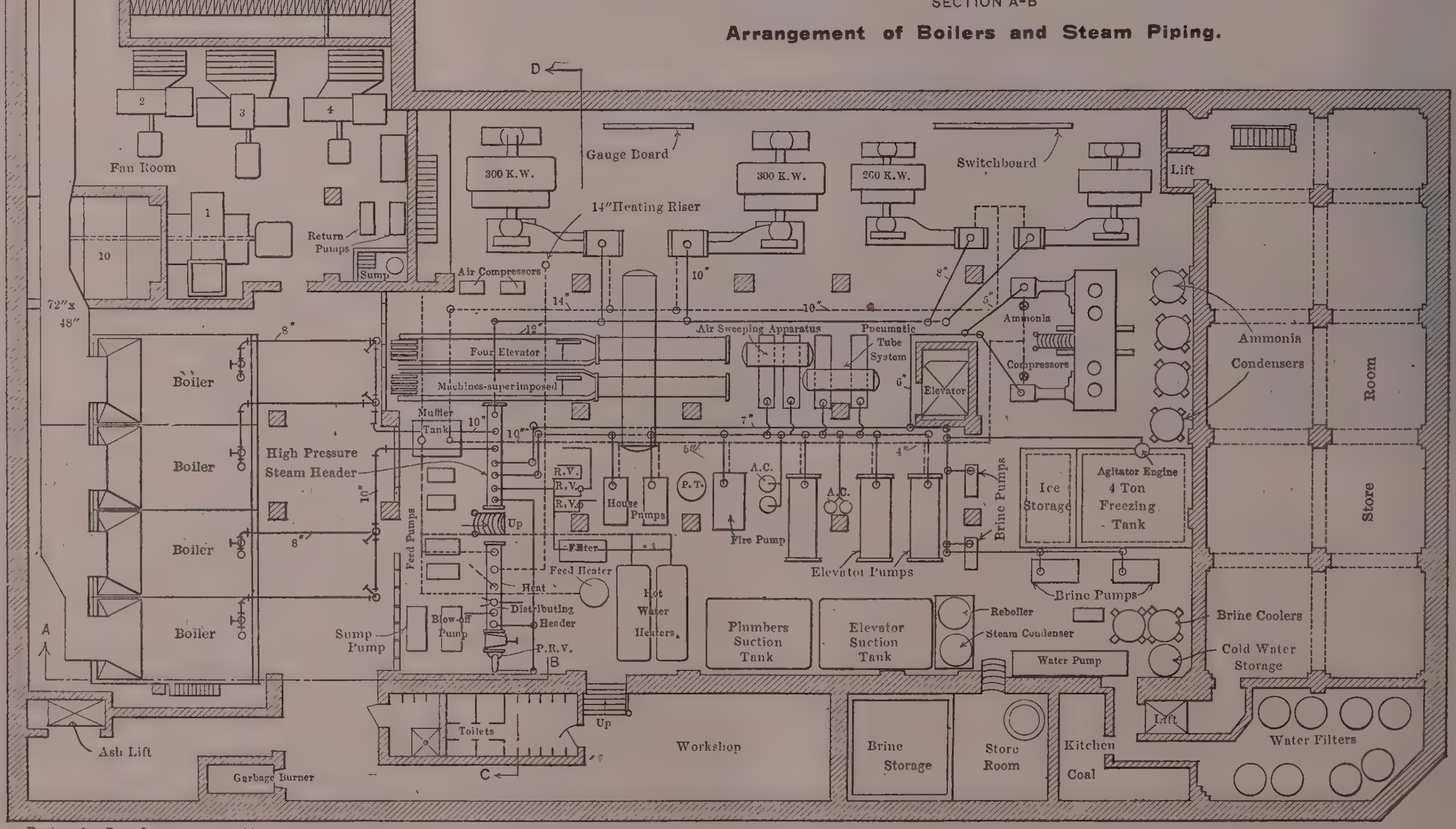
SECTION C-D

Details of Steam Header Arrangement in the Machinery Room.



SECTION A-B

Arrangement of Boilers and Steam Piping.



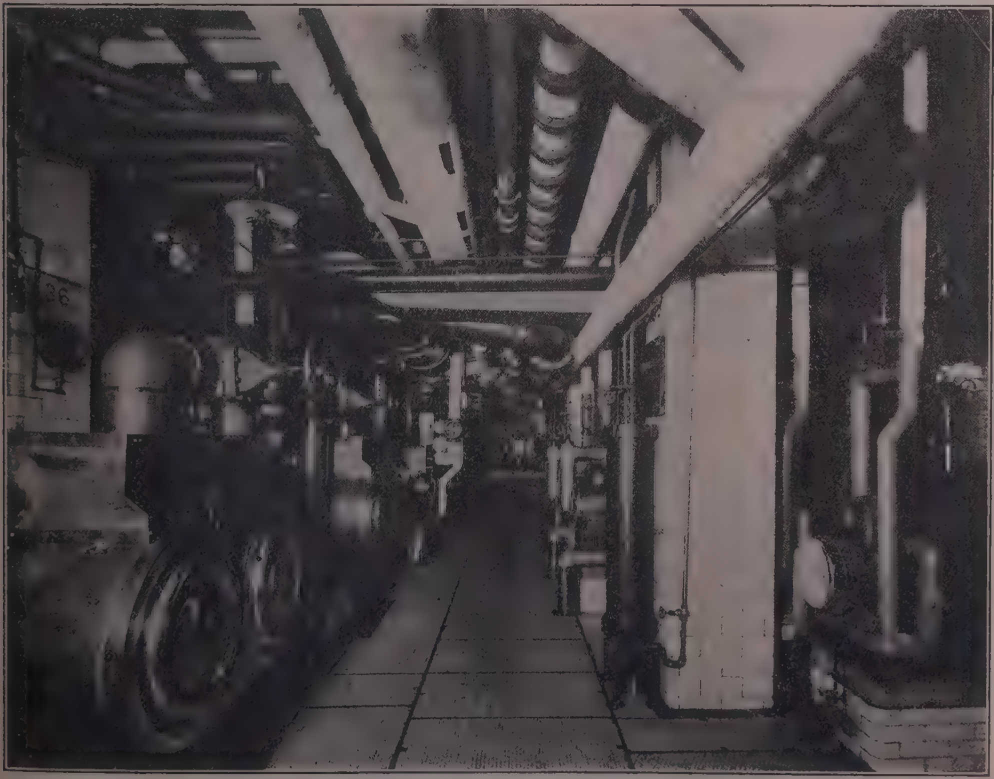
Arrangement of the Mechanical Equipment in the Sub-basement.

The steam supply connection to the radiation of the heating systems is rendered comparatively simple by the exclusive use of indirect heating on practically all floors of the building except the eighteenth. The three indirect systems upon the third, seventh and twelfth floors are supplied through the 14-in. riser main, which is carried up from the exhaust-steam header through a pipe riser shaft alongside the elevators to the top of the building, from which 6-in. branches are taken off to each equipment of heating coils; above the twelfth floor it is continued as a 10-in. line to the top floor for the supply of direct radiation. The tempering coils of the second-floor ventilating systems are supplied, together with the radiation at the entrances, by a 5-in. line, from the exhaust steam header. These pipe lines are of heavy wrought iron with screw flange joints throughout, and the risers are anchored at the third and fourteenth floors with expansion joints midway between. They are all dripped through trap connections to the low-pressure return tank for which Kieley steam traps are used. All of the steam mains are covered with Keasbey magnesia sectional fittings, all canvas jacketed and banded.

Drip systems have been installed for both high and low-pressure piping, with collecting tanks into which the condensation is pumped or trapped for removal. The high-pressure drip system has connections to all power mains and branches at pocket points and valves and other locations where condensation may accumulate, each line of piping and apparatus having a separate drip line and steam trap. The low-pressure drip system has connections to various portions of the exhaust mains and branches to the cylinders of all engines, pumps and refrigerating machinery, and to the exhaust head, to the muffler tank, to the feed-water heater, to the low-pressure distributing header, and to the hot-water heaters. The drips from the exhaust pipe from each engine and pump are trapped separately, each having a bypass with three valves. The high-pressure drip tank is a cylindrical steel-plate tank, 4 ft. in diameter by 6 ft. long, with a cooling coil embracing 60 linear feet of 3-in. pipe, into which the high pressure drips are delivered. This tank is located in the depressed portion of the machinery room, adjacent to the feed pumps, and condensation is delivered from it to the receiving tank for boiler feeding by an automatic 6x4x6-in. duplex steam pump. The low pressure drip tank is of similar construction, but 3 ft. in diameter by 5 ft. long, and has a cooling coil of 35 feet of 3-in. brass piping. Condensation is removed from this tank to the sewer by a pump of similar size, both pumps being automatically controlled by Kieley pump governors.

An interesting and very convenient provision has been made by the operating engineer at this plant for facilitating quick and accurate locations of any of the piping connections, valves and other fittings and apparatus for all systems in the building in which pipe connections are used. For this purpose a book with reduced-scale floor plan drawings for each floor of the hotel were prepared, showing with as little detail as possible the location of all apparatus—particularly in the power plant in the sub-basement, but also in the basement and all upper floors; on these plan diagrams are also shown the location of building columns which are designated by the numbers given during construction. Accompanying this list of floor diagrams are a series of schedules for all systems of piping installed, including high-pressure steam for all purposes, low pressure steam, drip lines, hot and cold water domestic supply, lines for refrigeration, vacuum cleaner system, water piping, and other equipment and fittings, in which is indicated the location of each main or branch relative to the nearest building columns, together with the sizes of all pipe. Then, as all building columns in the sub-basement, basement and wherever else possible, have their numbers plainly lettered on them, it is more than ordinarily convenient to determine the identity of any piece of piping or apparatus by referring to the schedule. The diagrams and schedule have been prepared in blue-printed form, 9x12 in. in size, so as to be conveniently handled by workmen in the location of parts of the various systems. It is found that very frequent reference is made to this schedule by the workmen at the building, both in the location of concealed piping and in determining the purpose and identities of the various pipe systems in congested spaces. The value of this system is especially to be noted in that a strange workman, entirely unacquainted with the arrangement of apparatus in the building, can by reference to it at once place himself in touch with the entire mechanical plant and complicated piping systems.

View in the Boiler Room, Showing Coal Handling Runway.



View in Pump Section of the Machinery Room.

Engines and Generators.—For the supply of electricity for lighting and power purposes in the hotel a 1,000-kw. generating plant, consisting of four slow-speed direct-connected generating units, has been installed. Two of these are of 300-kw. capacity each, and the remaining two of 200-kw. capacity, each consisting of a Western Electric multipolar slow-speed generator direct-connected to a Harrisburg four-valve simple horizontal engine. The two smaller engines have 20x20-in. cylinders and operate at 200 r.p.m., while the larger engines have 25x25-in. cylinders and operate at 150 r.p.m. The engines involve the standard valve and governor construction of the Fleming engine of the Harrisburg Foundry & Machine Co., and were installed by McKenzie, Quarrier & Ferguson, New York, under a steam consumption guarantee of 24 lb. of dry steam per horse-power hour.

The generators are engine-type multipolar machines direct-connected to their engines and are wound to deliver at 220 volts, at which voltage all lighting and power apparatus is operated. The generators are all over-compound to four per cent. to insure uniform voltage with changes of load and are designed for overload capacities which will permit operation at 25 per cent. overload for three hours without excessive heating. The electrical distribution system installed in the hotel is on the two-wire system, all power and lighting feeders being kept separate and under distinct control at the switchboard. All blower motors for other purposes are wired on separate feeders and have independent switches and circuit breakers on the main switchboard in the engine room so as to be at all times under control of the operating engineer. The lighting is controlled through groups of three panel boards on each floor, each floor being supplied by a separate feeder from the main switchboard.

The switchboard is a ten-panel white marble board with two panels for generator circuits and instruments, two totalizing panels, one for the power circuits and the other for the lighting, three panels for the power control and the three remaining for the lighting service. The equipment of the switchboard includes Weston instruments, Thompson recording meters for recording total current outputs, and I-T-E circuit breakers. The generating equipment and electrical wiring installation in the hotel were installed by the Western Electric Co., New York.

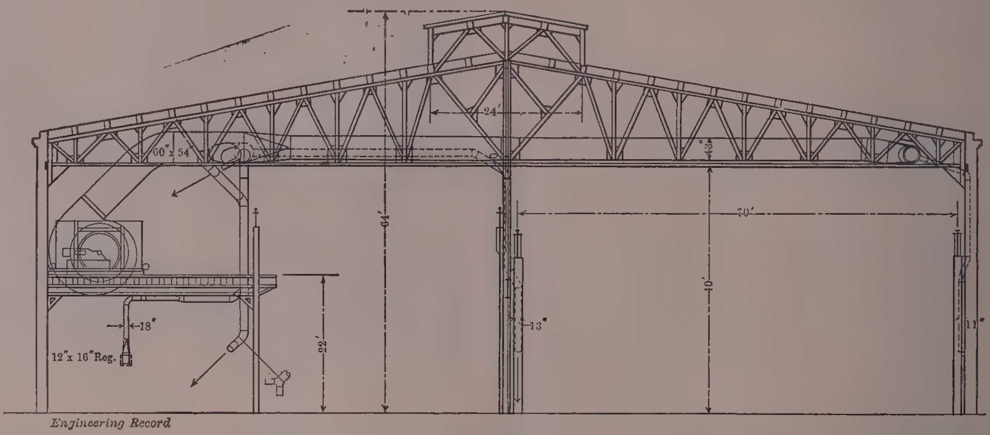
The boiler plant and steam equipment of the hotel, together with the heating and ventilating equipment referred to in an article in the preceding issue, were designed by Alfred R. Wolff, consulting engineer, New York. The electrical equipment of the building was designed by Pattison Bros., electrical engineers, New York. The architects of the building were Messrs. Trowbridge & Livingston, New York. The operating engineer in charge of the mechanical equipment of the hotel is Mr. J. C. Jurgensen.

An Exhaust-Steam Regeneration and Utilization Plant.

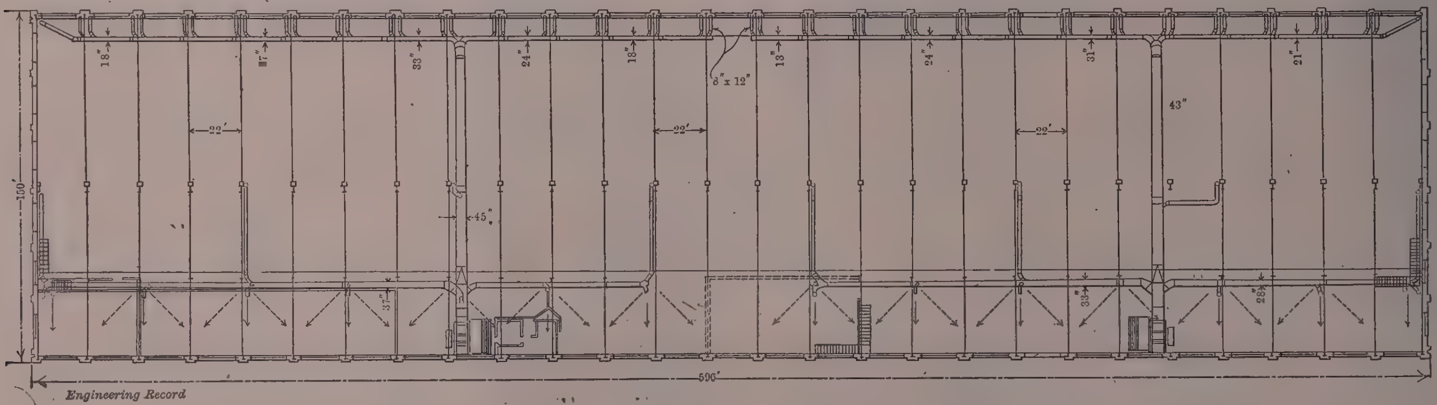
An exhaust steam regeneration and utilization plant on the Rateau system has been installed at the Hallside works of the Steel Company of Scotland, by which from 200 to 450 kw. are made available by the utilization of exhaust steam from a number of reciprocating engines, including a cogging engine, a finishing-train engine, two small mill engines, one 10-ton and three 4-ton steam hammers, all of which are high-pressure and operate intermittently. The generator operates on the principle that water, although at lower temperature than 212° F., will still evaporate, provided that a pressure less than atmospheric is maintained in the vessel containing it. Steam exhausted into the regenerator passes through a mass of water, which is violently circulated, causing the whole of the water in the vessel to absorb the heat units in the steam which occurs during the periods of exhaust from the main engines; the moment that the main engine ceases running, the water, owing to the fact that the pressure is reduced in the vessel, commences to re-evaporate, and supply the low-pressure steam turbine. The regenerator is in two compartments, one a steam receiver which provides both for separating oil from the steam and decreasing the violence of the shock resulting from steam meeting the water. The regenerator was designed to permit of continuous operation of two 700-h.-p. turbines through stops of the main engines of 45 seconds' duration, but it has often maintained the single turbine now installed in operation for six minutes with the main engines idle. The turbine is an eleven-wheel Rateau turbine of 700 h.-p. capacity at 1,500 r.p.m., and operates with an admission pressure never more than 12 lb. absolute.

Heating and Ventilating Plant for the Shops of the Southern R. R. at Spencer, N. C.

A heating plant of modern design has been installed in the new machine shop building of the Southern Ry., at Spencer, N. C., which building has been completed recently in the course of extensive improvements made by the railroad company at that point. This building is the most important of the group of shop buildings, having a ground plan of 150x600 ft., and embracing an interior volumne of about 4,500,000 cu. ft. in a single room. For the heating service it was decided to use the indirect steam heating system with fan blowers. Owing to the size of the building two heating equipments have been installed, one for either half of the building, to avoid the excessively large equipment that would have been required had only one plant been provided. Each heating system is therefore called upon to serve an extensive interior volume, but the heating requirements at Spencer are, however, moderate as compared with the more northern locations, the guarantee required of this heating installation being to maintain a uniform temperature inside of 60° Fahr., with the minimum outdoor temperature of 10° Fahr. It is the intention of the design of the system to change the air within the shop about twice per hour.



Cross Section of the Machine Shop Building.



Arrangement of Heat Distributing Ducts in the Machine Shop.

The building is of brick and steel construction, with a low roof surmounted by a monitor, carried on side wall and center columns located for clear spans of 73 ft. center to center. Extensive side window lighting has been provided, the walls being composed largely of glass; the monitor is also fitted with sash for the entire length on both sides. The amount of glass exposure in the side walls amounts to nearly 40 per cent. of the side wall construction, each 22-ft. side wall panel having a 15-ft. window, 26 ft. in total height. The monitor has nearly 3 sq. ft. of glass on either side per foot of length of the building.

The roof is of tar and gravel carried on steel roof trusses, the lower chords of which are located for a clear head room of 40 ft. below them. A fortunate feature of the roof-truss construction is that it accommodates the delivery duct work for the heating and ventilating system, so that all space beneath the lower chords is left free for the traveling crane service, and work in the shop.

The heating fans and steam coils have been located in the gallery at points indicated in the plan drawing from which the delivery connections are made to the overhead delivery duct lines above. They consist of special full-housed steel-plate Sturtevant fans each direct driven by a horizontal 10x10-in. center crank engine, the exhaust steam from which is utilized in cold weather in the heating stacks. The fans have wheels 9½ ft. in diameter by 4½ ft. face, the capacity of which is 60,000 cu. ft. per minute. Each fan has an outlet arranged to discharge at an angle of 45 deg. upward, the outlet being 54x60 in. in section. These outlets connect to a 45-in. circular delivery pipe extending cross-wise of the shop, and to two smaller longitudinal delivery connections extending toward the ends and the middle of the building, the sizes of which are indicated in the plan drawing.

The duct system for the delivery of air is of interest for the thorough manner in which provision has been made for the distribution. The discharge pipes have been arranged with care to distribute evenly throughout the building, all outlets having been located within about 10 ft. of the floor and arranged to deliver at angles of 45 deg. with the latter. Those on the outer wall are carried down in pairs of 8x12-in. ducts on either side of the windows, as shown, with outlets inclined toward different directions; this arrangement was resorted to, owing to the impossibility of securing at these points sufficient space behind the crane runways for single pipes, and the individual pipes have been located in wall chases in the brick construction on either side of the steel wall columns. The concealment of these ducts in chases was especially desirable in the shop, both to avoid interference with the traveling crane equipment and to be free from injury owing to the nature of the work within the shop. The delivery outlets in the middle of the building, which are distributed at every third or fourth building column, consist of 13-in. down connections, each with two 11-in. outlet openings directed at 45 deg. angles in opposite directions. For the heating of the space beneath the gallery, 15-in. down connections are made at every second or third column line, with double 11-in. inclined outlet openings, as at the middle. The heating supply for the gallery consists of 9-in. openings spaced similarly for those underneath the gallery, which deliver downward at an angle of 45 deg. into the gallery space.

The heating equipment for each fan consists of standard Sturtevant heater sections containing 10,528 ft. of 1-in. pipe each. These heaters are so proportioned that they are together capable of maintaining the building at 60° temperature with 5-lb. steam pressure, when the fans are operated to full capacity. Steam is supplied from the power plant of the shops nearby, heating being accomplished by exhaust steam from the blower engines. The heaters have by-pass connections for the operation of the system in the summer without heating. Owing to the elevated location of the heating equipments in the gallery, the water of condensation is returned to the power plant by gravity. The equipment for this installation was supplied by the B. F. Sturtevant Co., Hyde Park, Mass., the system having been designed and installed by C. H. Gifford & Co., representatives of the Sturtevant Co., at Philadelphia. Mr. A. Stewart is mechanical superintendent of the Southern Ry. Co., and Mr. D. W. Lum, chief engineer of maintenance of way and structures

PRIVATE REFRIGERATOR CAR LINES will doubtless be partially superseded on the railroad systems controlled by the Harriman interests, by whom 6,000 such cars have recently been purchased. The fruit crop of California, amounting to approximately 30,000 cars a year, is carried by the Santa Fé system and the Harriman lines. The Santa Fé system has between 5,000 and 6,000 refrigerator cars available for handling its share of the traffic, while the Harriman lines have heretofore relied chiefly on independent private car lines.

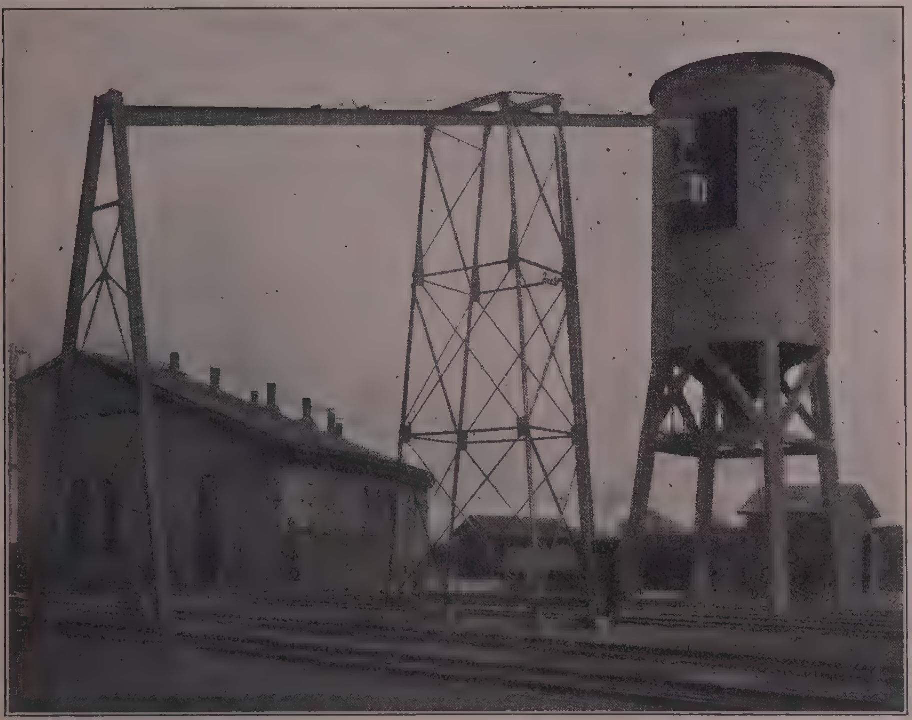
An Ash Handling Plant for the Sante Fe R.R.

An ash-handling plant, with a capacity of 25 tons an hour, has recently been completed in the division terminal yards of the Atchison, Topeka & Santa Fe R. R. at Argentine, Kan. A concrete pit 135 ft. long is placed under each of four parallel tracks at the plant, which is near an engine house. An elevated reinforced-concrete storage bin, on a four-post reinforced-concrete tower, is built at one side of these four pits. The latter are spanned transversely at the center by a trolley track which is carried on steel towers and extends into the storage bin through an opening in the side of the latter near the top.

Four ¾-ton rectangular steel buckets, fitted with a bail, are at present provided for each of the pits under the tracks, and three additional buckets for each pit will be installed in the near future. Each bucket sets loose on a four-wheeled truck on a track laid on the concrete bottom of the pit, so it may be moved to suit the location of the locomotive over the pit. The trolley track consists of a 12-in. I-beam. The trolley is of special design and carries a block and fall with which the buckets are lifted from the pits. An electrically operated Lidgerwood hoist in a small building back of the storage bin raises and lowers the buckets and hauls the trolley along its track. The buckets are dumped automatically by a trigger near the end of the trolley track in the storage bin.

The reinforced-concrete storage bin, which has a total height of about 60 ft., will hold 75 tons of cinders. It has a flat concrete slab roof and a conical hopper bottom, also built of concrete. The hopper is fitted with an under-cut gate that is operated from the ground. A track is laid under the storage bin between the posts of the tower and parallel to the cinder pit tracks. The cinders are stored in the bin until the latter is about filled when they are dumped into gondola cars through the gate in the bottom and removed. The plant is capable of serving on the average 150 locomotives every 24 hr.

The plant was designed and built by Roberts & Schaefer Co., consulting engineers and contractors, of Chicago, under the direction of Mr. E. E. Barrett, principal assistant engineer for that company.



Ash Handling Plant at Argentine, Kans.

The Value of Pure Water.—I.

By George C. Whipple. One of several papers prepared in commemoration of the twenty-fifth anniversary of the doctorate of Prof. William T. Sedgwick.

In order to estimate the relative value of waters which differ materially in quality, it is necessary to have some common denominator. Nothing better for this purpose has been suggested than the dollar, which in this paper is made the basis of computation. By ascertaining what different characteristics of water cost the consumers, and by finding out how much consumers are willing to pay to avoid using waters which possess certain characteristics, an attempt has been made to secure a reasonable basis of comparison. The results of this initial study are here presented. They must not be taken too seriously at present, as some of the involved assumptions have not been established beyond doubt; and with the accumulation of certain data, necessary but not as yet obtainable, the results must be somewhat modified. Yet the general conclusions ought not to be far astray, and, from a study of the best data available, the writer believes that they err on the side of conservatism rather than on the opposite side. The suggested method of calculating the value of pure water seems to be one capable of being refined to a degree where its results will be of great practical value. The lines along which the accumulation of data is necessary in order to render the method reliable will be evident from a perusal of the text.

Pure and Wholesome Water.—To define the meaning of the expression pure and wholesome water, which is so often found in water-supply contracts, would seem to be an easy matter, after all the study that has been given to the subject in recent years. Everyone knows in a general way what is implied by this expression, but when it comes to framing a definition in positive scientific terms the problem is not as easy as it seems. This is not because the chemist and the biologist do not know what pure water is, but because water has many attributes which have to be taken into consideration, and because these attributes vary greatly in importance. Pure and wholesome water is not a substance of absolute quality. Strictly speaking, pure water does not exist in nature; all natural waters contain substances either in solution or suspension; and in proportion as these substances are present, and in proportion as they are objectionable in character, the water is impure. Definitions of pure and wholesome water, therefore, generally state what foreign substances shall not be present, or in what amounts they are permissible, instead of defining the positive qualities which the water shall possess.

Unquestionably the term pure and wholesome water, as ordinarily used, relates to water intended to be used for drinking. Such a water must be free from all poisonous substances, as the salts of lead; it must be free from bacteria or other organisms liable to cause disease, such as the bacilli of typhoid fever or dysentery; it must also be free from bacteria of fecal origin, such as Bacillus coli. In other words, the water must be free from poisonous substances, from infection, and even from contamination. (Considering this term to mean pollution with fecal matter; contamination must be taken as potential infection.) Besides this, it must be practically clear, colorless, odorless and reasonably free from objectionable chemical salts in solution and from microscopic organisms in suspension. Moreover, it must be well aërated. Color, turbidity, odor, dissolved salts, and so forth, may be permissible to a small degree without throwing the water outside of the definition of pure and wholesome water. In these minor matters local standards govern up to a certain point, and it is in regard to them that differences in the judgment and experience of analysts lead to different classifications.

When it comes to using water for other purposes than for drinking, other attributes have to be considered. Hardness makes a water troublesome to wash with and to use in boilers; iron makes trouble in the laundry; chlorine corrodes pipes and makes work for the plumbers; the presence of the carbonates and sulphates of lime and magnesia affects the paper-maker, the brewer, the tanner, the dyer, the bleacher; soda causes a locomotive boiler to foam, and affects the use of the water for irrigation. All of these constituents, and others which are not named, have to be taken into consideration in connection with a public water supply, which may be put to any of these uses.

If it is a difficult matter to define a pure and wholesome water in strict scientific terms, it is still more difficult to compare waters which differ in purity on any reasonable basis; and yet this often has to be done. Given two water sources equally available to a city for purposes of supply, both safe to drink, but one high-colored and soft, the other colorless and hard—which is the better selection? A water-works plant is to be appraised: structurally the system is a good one but the quality of the water is unsatisfactory because of its excessive color or turbidity—how much should be deducted from the value of the works because of the bad quality of the water? The water-works owned by a private company are to be purchased by the city; the city has a high typhoid fever death-rate due unquestionably to the water supply—how much less should the city pay because of that fact? A city in the West is using turbid river water—how much can it afford to pay to filter it? A city in New England is using a water so heavily laden with Anabaena that it is nauseous to drink—how much can the city afford to pay to procure a new supply? These are all practical, everyday questions which deserve answers based on scientific data.

In valuation cases, where the quality of the water supply has been unsatisfactory, the cost of filtration, or other appropriate method of purification, has been sometimes taken as a measure of the inferior quality of the water, and this amount deducted from the value of the works. In case filtration was impractical, or more expensive than securing a supply from a new source, the additional cost of such new supply has been sometimes taken as a measure of the inferior quality of the works and the amount deducted from the value of the works. Both of these methods are similar in that they contemplate the substitution of a satisfactory water for one not satisfactory.

Another method of measuring the depreciation applicable to a water-works plant because of an inferior quality of the supply would be to ascertain what the use of the impure water has cost the consumers, compared with what a pure and satisfactory water would have cost them. This method has not been used in practice, but it seems to be a reasonable one, and one which would be of more general application than the preceding, if the data upon which it is based could be accurately determined. Unfortunately, this is not the case in many instances, but by the use of certain generalized data and assumptions, results may be secured which are of considerable use in comparing the value of waters different in quality.

The qualities of a public water supply which most affect the ordinary consumer are: 1. Its sanitary quality; that is, its liability of infection with disease germs or substances deleterious to health. 2. Its attractiveness, or lack of attractiveness, as a drinking-water. 3. Its hardness, so far as this relates to the use of soap in the household. 4. Its temperature, so far as this relates to drinking.

Characteristics which affect industrial uses are too much a matter of local concern to be taken into account in a general discussion although they are by no means of small account, and in some communities their importance might control. The qualities selected are to be considered as illustrative of the method rather than as a complete exposition of it.

The problem is to express these four characteristics in terms of dollars and cents to the consumer. The financial standard is certainly not the highest one for judging the quality of a water supply when the public health is concerned; human life cannot be estimated in gold dollars, and the smell of unsavory water to a thirsty man cannot be reckoned in dimes; nevertheless, the financial basis is a convenient one, and one necessarily involved in all questions which relate to public utilities.

Sanitary Qualities.—If the water under consideration has been used for a considerable time, the typhoid fever death-rate of the community will fairly well represent the sanitary quality of the water supply. It will not tell the whole story, but in most cases it will not lead far astray. In order to reduce this to a financial basis, it is necessary to make several assumptions.

The financial value of a human life is generally taken as $5,000, but according to Mr. M. O. Leighton it varies at different ages from $1,000 to $7,000, as shown by Table I. It so happens that persons are most susceptible to typhoid fever near the age when their life-value is considered greatest. By combining the life-value at different ages with the age distribution of persons dying of typhoid fever, the resulting average value of persons dying from typhoid fever is found to be $4,634, which is very close to the figure ordinarily used.

TABLE I.

RELATION BETWEEN ESTIMATED VALUE OF HUMAN LIFE AND TYPHOID FEVER RATE.

Age	Estimated Value of Human Life	Per Cent of Deaths from Typhoid Fever	Product of Columns 2 and 3
0-5 years	$1,500	5.0	$ 7,510
5-10 "	2,300	5.9	13,570
10-15 "	2,500	7.2	18,000
15-20 "	3,000	13.1	39,300
20-25 "	5,000	16.7	83,500
25-30 "	7,500	13.2	99,100
30-35 "	7,000	9.9	69,300
35-40 "	6,000	8.0	48,000
40-45 "	5,500	5.6	30,900
45-50 "	5,000	4.0	20,000
50-55 "	4,500	3.3	15,000
55-60 "	4,500	2.6	11,700
60-65 "	2,000	2.1	4,200
65-70 "	1,000	1.5	1,500
70- "	1,000	1.9	1,900
Total		100.00	$463,480

Average value of life of persons dying from typhoid fever, $4,634.

The percentage mortality of typhoid fever patients is sometimes stated as 10 per cent; that is, ten cases for every death. Figures of this character are most often based on hospital records, and mild cases do not generally reach the hospitals. Studies of recent typhoid epidemics indicate that 15 to 18 cases for each death would be nearer the truth. The expense of medical treatment, nursing, and medicine, the loss of wages for a month or more, together with other attending expenses and inconveniences, would doubtless aggregate at least $100 per case, or $1,000 for the 10 cases corresponding to one death. If the estimate of $100 is considered too large, it may be answered that the excess is more than offset by the fact that there are more often from 15 to 18 cases for each death than there are 10. It may be fairly assumed, therefore, that $6,000 is a very moderate estimate of the financial loss to the community from typhoid fever for each death from that disease.

Typhoid fever is by no means the only disease transmitted by contaminated water. Dysentery and various other diarrheal diseases precede it or follow in its train, and in most instances these are probably due to the same general sources of contamination as those which caused the typhoid fever, although, of course, to different specific infections. The reduction of the typhoid fever death-rate following the substitution of a pure water for a contaminated water is often accompanied by a drop in the death-rate from other diseases. Thus, if the five years before and after filtered water was introduced into Albany, N. Y., are compared, it will be seen that the reductions in deaths from general diarrheal diseases and the deaths of children under five years of age were much greater than in the case of typhoid fever. There was also a reduction in malaria, but this probably represents faulty diagnosis of typhoid fever cases before the introduction of the filters, rather than a real reduction of malaria. That the reduction of infant mortality and deaths from diarrheal diseases was not due to other conditions seems probable from the fact that in the neighboring city of Troy, N. Y., where the water supply was not changed, there was no such diminution during the same period, as may be seen in Table II.

Mr. Allen Hazen, in his paper on Purification of Water in America, read at the International Engineering Congress at St. Louis, called attention to this same fact, that after the change from an impure to a pure supply of water the general death-rate of certain communities investigated fell by an amount considerably greater than that resulting from typhoid fever alone—indicating either that certain other infectious diseases were reduced more than typhoid fever, or that the general health tone of the community had been improved. Thus, for five cities where the water supply had been radically improved he found:

	Per 100,000
Reduction in total death-rate in five cities with the introduction of a pure water supply	440
Normal reduction due to general improved sanitary conditions, computed from average cities similarly situated, but with no radical change in water supply	137
Difference, being decrease in death-rate attributable to change in water supply	303
Of this, the reduction in deaths from typhoid fever was	71
Leaving deaths from other causes attributable to change in water supply	232

From these facts it is evident that to place the financial loss to a community as $6,000 for each death from typhoid fever due to the public water supply is to use too low a figure. It probably ought to be several times as high; but recognizing the lower financial value placed on the lives of infants, and the less serious character of the other diseases, and wishing to be as conservative as possible, for the reason that typhoid fever is not entirely a water-borne disease, $10,000 per typhoid death has been used in the calculation which follows.

TABLE II.

EFFECT OF FILTRATION ON DEATH-RATES AT ALBANY, N. Y., AND A COMPARISON WITH TROY, N. Y., WHERE THE WATER WAS NOT FILTERED.

	Death rates per 100,000			
ALBANY	1894-98, before Filtration at Albany	1900-1904 after Filtration at Albany	Difference	Per Cent. Reduction of Death Rates
Typhoid fever	104	26	78	75
Diarrheal diseases	125	53	72	57
Children under 5 years	606	309	297	49
Total deaths	2,264	1,868	378	17
TROY				
Typhoid fever	57	57	0	0
Diarrheal diseases	116	102	14	12
Children under 5 years	531	435	96	18
Total deaths	2,157	2,028	129	6

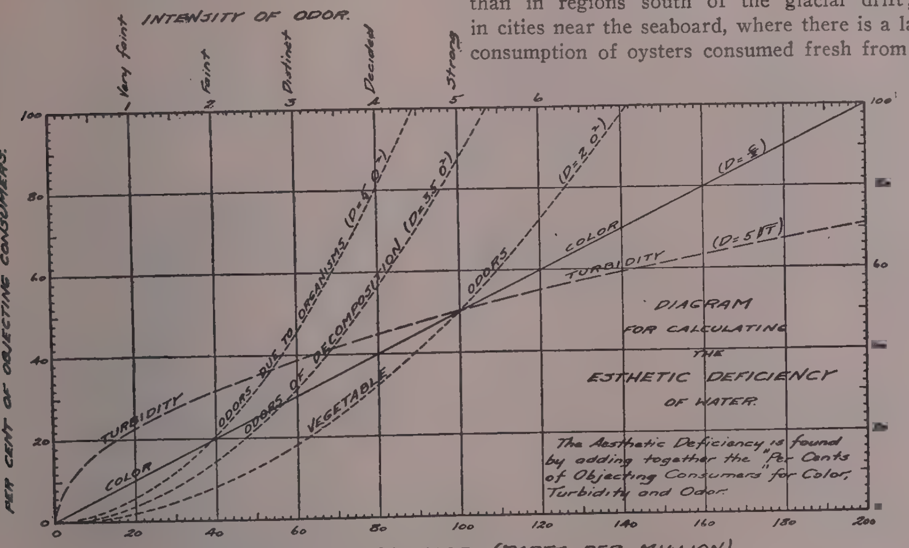
Remark: Filtered water was introduced into Albany in 1899. The water supply of Troy has remained practically unchanged.

Since typhoid fever is a disease which may be transmitted in other ways than by the water (as, for instance, by milk, shell-fish, flies, etc.), it is necessary to allow a certain death-rate for these other causes, for even in a city where the water supply is perfect there may still be some typhoid fever. To establish this "normal," which must not be assumed to mean necessary typhoid, is a difficult matter, but for purposes of calculation we may assume it to be determined and represent it by the letter N.

If we assume that all typhoid fever in excess of N is due to the water supply, and if we assume that the daily consumption of water is 100 gal. per capita, then letting T equal the typhoid fever death-rate per 100,000:— $(T - N)\ 10{,}000 =$ loss to the community in dollars for $365 \times 100 \times 100{,}000$ gal. of water, or $D = \frac{(T - N)\ 1{,}000}{365}, = 2.75\ (T - N)$, where D stands for the loss in dollars per million gallons of water used.

Suppose the average typhoid fever death-rate for a community which has a somewhat polluted water supply has averaged 43 per 100,000 for a period of five years, and suppose that for this place the value of N is estimated as 15, then— $D = 2.75\ (43 - 15) = \$76.72$ if the per capita consumption is 100 gal. If the consumption per capita is 115 gal., D would be 100/115 of \$76.72, or \$66.71; if it were 63 gal. per capita, then D would equal 100/63 of \$76.72, or \$121.77.

The value of N must be naturally subject to local variation, and in order to obtain an idea as to its probable value, a compilation of typhoid fever death-rates has been made for cities and towns in different parts of the country which use ground waters or filtered waters—that is, waters which may be considered as free from contamination. A generalized summary of them is given in Table III.



The Theoretical Esthetic Rating of Water.

TABLE III.

TYPHOID FEVER DEATH-RATES IN CITIES AND TOWNS WHICH HAVE GROUND-WATER SUPPLIES.

State	Number of Cities and Towns Averaged	Number of years Averaged	Average Typhoid Fever Death-Rate per 100,000
Maine	2	5	6.4
Massachusetts ..	23	5	15.8
Connecticut	4	5	9.5
New York	13	5	24.7
New Jersey	10	1	20.5
Pennsylvania ...	5	1	31.8
Ohio	22	5	32.4

There is reason to believe that the higher rates given above do not correctly represent the situation, because in some instances the ground water was supplemented by the occasional use of water which may have been polluted. Proximity to a large city where the water supply is contaminated was also responsible for some of the high figures; so also was the absence of sewerage systems. Nevertheless, there seems to be a slight tendency for the typhoid fever rates to increase in the United States from north toward the south in those places where the water supply is reasonably safe. There are some exceptions to the increase southward, however. Thus, in Camden, N. J., which is supplied with a pure ground water, the typhoid rate was only 12 in 1901 and 20 in 1902.

In Fuertes' book on Water and the Public Health a diagram is given showing that the typhoid fever death-rates in cities supplied with ground water vary from 5 to 32 per 100,000 in America, and from 6 to 33 per 100,000 in Europe, the average being about 18 in America and 19 in Europe. It is shown also that the death-rates from cities supplied with filtered water vary from 4 to 20 in America, and from 4 to 20 in Europe, the average being 12 in both cases. Recent American data for cities supplied with filtered water show that the rates are somewhat higher than these, the average being somewhat less than 20.

Taking into consideration the best available data, it seems reasonable to place the general value of N somewhere between 10 and 25 per 100,000, with the most probable average value as 20, which figure may be used in the equation where local sanitary conditions are unknown. The value of N, however, should be varied where there is reason for doing so. Where the sanitary conditions are good 15 may be taken as a fair value. In New England it might be placed lower than in regions south of the glacial drift; in cities near the seaboard, where there is a large consumption of oysters consumed fresh from the layings, the value of N might be higher than in inland cities, where the oyster consumption is small and where fattened oysters are not used as freely; in cities where there are cess-pools, but no sewers, the value of N would naturally be higher than in cities well provided with sewers.

It may be reasonably expected that, as time goes on, the value of N will gradually fall, because of a general decrease of typhoid fever in the country at large, and a consequent diminution of the number of foci of infection. Statistics for twelve states, including all the New England states, New York, New Jersey, Maryland, California, Minnesota, and Michigan, show that during the last quarter of a century the general typhoid fever death-rate has fallen, as shown in Table IV.

Attractiveness.—The analytical determinations which relate to the general attractiveness of a water are those of taste, odor, color, turbidity, and sediment. As these quantities increase in amount, the water becomes less attractive for drinking purposes, until finally a point is reached where people refuse to drink it. In order to use these results in a practical way, it is necessary to combine them so as to obtain a single value for the physical characteristics or, as they say abroad, for the "organoleptic" quality of the water. An attempt has been made by the author to obtain what may be termed an esthetic rating of the water, and the result is shown in the accompanying diagram.

This diagram, it should be said, is based almost entirely upon estimates and very little upon statistical data. It rests upon the assumption that people differ in their sensibilities, or their esthetic feelings as to the use of water. Some persons are much more fastidious than others in regard to what they drink. A water which would be shunned by one person, even though he were thirsty, might be taken by another with apparent relish. As a rule, people are more fastidious about the odor of water and the amount of coarse sediment which it contains than they are about its color and turbidity. This is perhaps natural, as a bad odor suggests decay, and decay is instinctively repugnant. Often, however, people do not discriminate between odors which are due to decomposition and those which are not. Habit and association have much to do with a person's views as to the attractiveness of water. In New England, where the clear trout brooks run with what Thoreau called meadow tea, few people object to a moderate amount of color, while they do object to a water which is very turbid. In the Middle West, where all the streams are muddy, it is the unknown colored waters which are disliked. People who are accustomed to well water object to both color and turbidity. With most people a fine turbidity, such as is produced by minute clay particles, is less a subject of complaint than an equal turbidity produced by comparatively coarse sediment. In the diagram an attempt has been made to reconcile these different points of view so as to put them, as well as may be, on the same footing. In this connection several series of comparisons were made, for which acknowledgments are due Mr. J. W. Ellms, of Cincinnati, Ohio, and Mr. Andrew Mayer, Jr., of Brooklyn, N. Y. Turbid waters were viewed through the eyes of a group of Western people, who made some comparisons with colored and turbid waters, while colored waters were viewed through the eyes of a group of students in New York, and vice versa.

TABLE IV.

FALL OF TYPHOID FEVER DEATH-RATE IN THE LAST 25 YEARS.

Year	Average Typhoid Fever Death-Rate per 100,000
1880	55
1885	46
1890	36
1895	28
1900	23
1905	21

The abscissæ of the diagram represent turbidity, color, and odor, as given in the ordinary water analysis. The ordinates represent the per cent. of objecting consumers. By this is meant the proportion of the water-takers who would ordinarily choose not to drink the water because of the quality indicated by the curve, or who would buy spring water, or bottled water, rather than use the public supply, if they could afford to do so. This number would increase, of course, as the general attractiveness of the water decreased. From the curves one may calculate what may be called the esthetic deficiency of the water by adding together the per cent. of objecting consumers for color, turbidity, and odor. If the esthetic deficiency equals 100, it indicates that the water is of such a character that everyone would object to it, and figures in excess of 100 only emphasize its objectionable character.

It will be seen from the diagram that when the color of water is less than 20, or the turbidity less than 5, only one person in ten would object to it, but when the turbidity or color is 100, one-half of the people would object to it. It may be thought that this proportion is too low, but it must be remembered that colored waters are invariably accompanied by a vegetable odor and often by a slight turbidity, and that it is the sum of the several quantities which determines the esthetic rating.

Experience has shown that objection to color varies directly with its amount; consequently this curve has been plotted from the equation, $p_c = \frac{c}{2}$, that is, a straight line, where p_c stands for the per cent. of objecting consumers, and c for the color.

In the case of turbidity, however, small amounts count for more, relatively, than larger amounts. The equation for the turbidity curve has been taken, therefore, as $p_t = 5\sqrt{t}$, where t stands for the turbidity.

With odor, however, the opposite condition prevails; faint odors count for little, but distinct and decided odors cause much more complaint. Consequently, the per cent. of objecting consumers has been made to vary as the square of the intensity of the odor expressed according to the standard numerical scale. The quality of the odor makes quite as much difference as its intensity, and for that reason three curves have been plotted, one representing vegetable or pondy odors (O_v), one representing odors due to decomposition (O_d), and one representing the aromatic grassy and fishy odors due to microscopic organisms (O_o). These curves are plotted from the following equations: $p_o = 5O^2_o$; $p_o = 3.5O^2_d$; $p_o = 2O^2_v$, in which O_o, O_d, and O_v stand for the intensity of the three groups of odors mentioned.

These curves represent somewhat imperfectly our ideas as to the relative effects of color, turbidity and odor; and on further study they are likely to be considerably modified.

It is a well-known fact that in cities which are supplied with water which is not attractive for drinking purposes, large quantities of spring water and distilled water are sold, and that consumers go to much expense in the purchase of house filters in order to improve the quality of the water furnished by the city mains. It is fair to assume that in any community the amount of money expended for bottled water and house filters will vary in a general way according to the attractiveness of the water, although there is no doubt that the presence of typhoid fever in the community, or the fear that the water is contaminated, will greatly increase the use of auxiliary supplies for drinking. For purposes of calculation it may be assumed that the diagram just described represents this tendency to use vended waters, and that each objecting consumer would go to the expense of buying spring water or putting in a house filter, if he could afford it. It may be argued, also that the poor consumer who may be unable to do this is as much entitled to satisfactory water as is the well-to-do consumer.

From a study of price-lists of spring waters sold in New York and other cities it has been found that the ordinary wholesale price of spring water is seldom more than 10 cents a gallon; in some places it is as low as 1 cent; the average is about 5 cents. To filter water through house filters costs less, but generally it is less satisfactory.

As a convenient figure for calculation, and as a most conservative one for general use, a cost of 1 cent per gallon to the ordinary consumer for an auxiliary supply of drinking-water (either spring water or well-filtered water) has been taken. In cities where the cost of procuring and distributing bottled water exceeds 1 cent per gallon, as it does in such a city as New York for example, this should be taken into account in making local use of the data. For the illustrative purposes of the present paper, and for general comparisons, the figure mentioned will serve as a satisfactory basis. The average person drinks about 1.5 pints of water per day, and therefore one-fifth cent per capita daily may be taken as a reasonable figure for the cost of an auxiliary supply. If the entire population used such a supply, and if the daily consumption of the public water supply were 100 gal. per capita, then one-fifth cent per hundred gallons, or $20 per million gallons, would represent the loss to the consumers due to an imperfect water supply which had an esthetic deficiency of 100. If the esthetic deficiency were less than 100, say 37, then the loss to the consumer would be 37/100 of $20, or $7.40 per million gallons. In other words, the figure for the esthetic deficiency divided by 5 gives the financial depreciation of the water supply in dollars per million gallons, or $D = 20\frac{p_c + p_t + p_o}{100}$.

Example: Suppose the turbidity of a water is 3, its color 65, and its odor 2*f* (that is, faintly fishy), because of the presence of microscopic organisms; then $D = 20\frac{12 + 32 + 20}{100} = \$12.80$; that is, the depreciation of the water, because of its unsatisfactory physical qualities, amounts to $12.80 per million gallons.

(To be continued.)

The Removal of Dust and Smoke from Chimney Gases.

The removal of dust and smoke from chimney gases is being successfully accomplished at the works of Rowntree & Co., York, England, by the air-washing process. The power plant of the works consists of five 8x30-ft. Lancashire boilers equipped with superheaters. The products of combustion pass through a Green economizer and formerly issued to the stack at 320° Fahr. The fuel used is a dusty bituminous slack about 310 tons of which are consumed per week. The gases enter the washer at a velocity reduced to about 4 ft. per second, meeting in the first section a plentiful spray of water heated to about 250° Fahr. Here most of the heavy grit is deposited.

The gases then pass through two more sections containing cold water sprays and thence to the stack through an induced draft fan. About 7,000 to 8,000 gal. of water are required to wash and cool the usual amount of 2,400,000 cu. ft. of hot gases per hour. All of the grit and dust and practically all of the smoke and the sulphur acids are removed from the gases in the washer; the amount of grit collected is about 1,600 lb. per 24 hours, nearly 1.5 per cent. of the amount of coal burned.

Progress of the New York Central & Hudson River R. R. Terminal Improvements in New York City.

The improvements and construction of the New York Central & Hudson River R. R. passenger terminal at 42nd St., New York, are steadily progressing, and notwithstanding the great amount of work which yet remains to be done to complete the new installation, a very noticeable progress can be observed by inspecting the yards or even when entering the depot by trains. About 25 per cent. of the estimated 2,500,000 cu. yd. of earth excavation has been completed, nearly all of the east side of the 43-acre depressed yard having been carried down to grade at an average of about 30 ft. below street level. Excavation is in progress for the 20-acre low-level yard at a maximum depth of 50 ft. below the street. The reconstruction is well advanced on the south end of the approach tunnel, which has been materially widened and the old arch roof replaced by a new flat roof supported on the side walls and intermediate columns.

All of the heavy buildings on the east side of the new yard have been underpinned where necessary, and new concrete footings carried down to rock, sometimes to a depth of 30 to 40 ft. below the former level. The high bank on the east side of the yard has been in many places protected by the construction of a very heavy concrete retaining wall about 21 ft. in height, of New York Central standard section, as illustrated in The Engineering Record of Jan. 6, last. The buildings for the transformer station at 50th St. and Park Ave., in the north end of the new yard, have been completed and the installation of electrical equipment in them is nearly complete. The erection of the steel columns and girders for the Park Ave. viaduct and for some of the transverse bridges is well under way, as well as some of the roof for the suburban station, about 6,000,000 lb. of steel being now assembled in place.

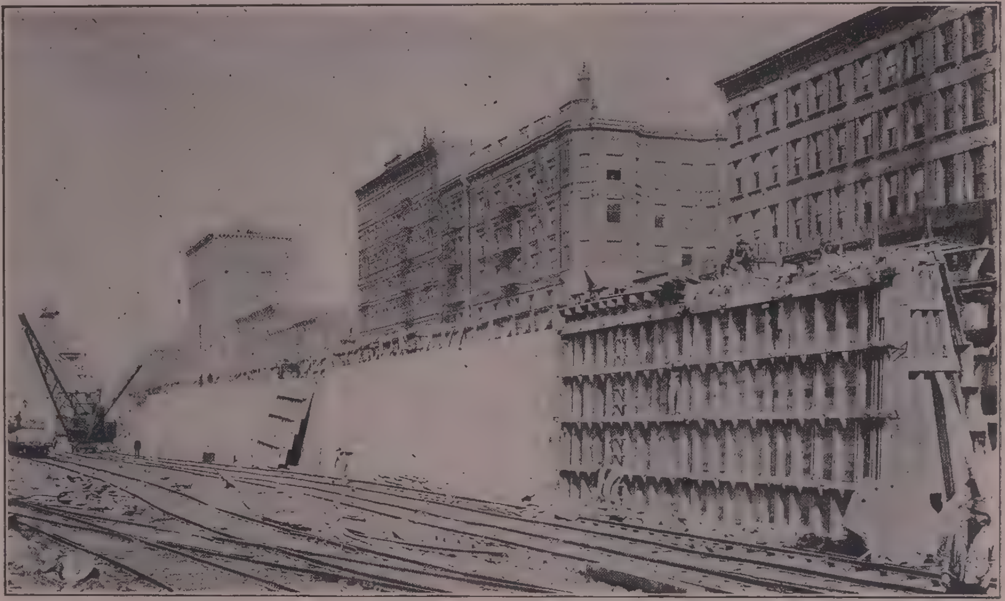
Erection of Transformer Station at 50th Street.

The contracts have been awarded for the north half of the twenty-story office building, and work will soon be commenced on the substructure of the main terminal station. Considerable of the permanent track and switches has been laid in the east yard. Besides these principal items, many minor features have been completed and are in progress, not to mention the important work constantly arising in the shifting and maintenance of the tracks and of the interlocking switch system for the operation of more than 1,300 train movements daily. The plant installed by the contractors remains substantially as enumerated in the description published Nov. 18, 1905, and the general methods of construction there described, and the plan of successive operations and the maintenance of service in temporary terminals on the east and west sides of the yard while the main tunnel is constructed, remains as outlined in the issue of this journal of May 26, last.

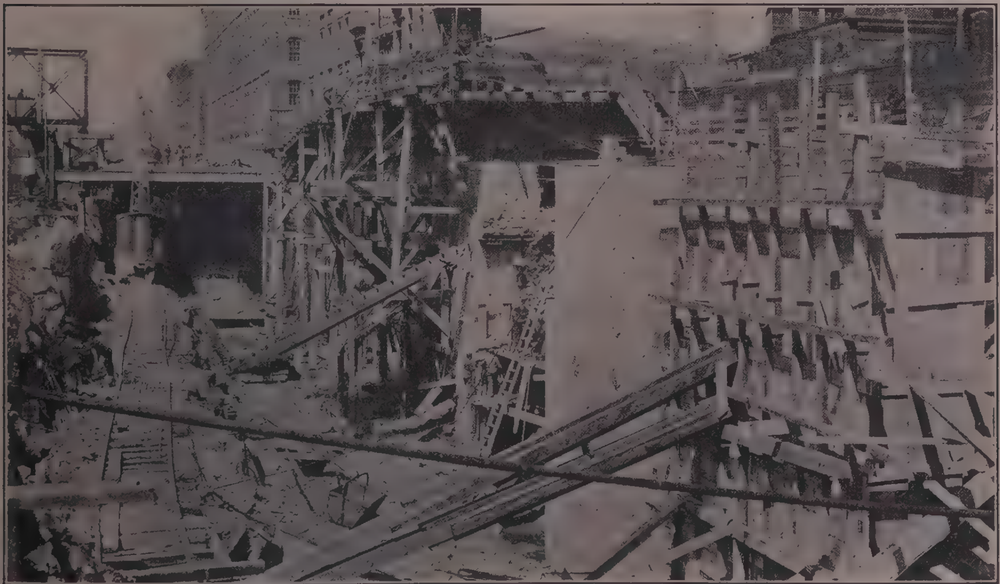
Of the 240,000 cu. yd. of concrete involved in the reconstruction a large proportion is included in the retaining walls. Their construction was commenced about a year ago, and those on the east side of the yard containing about 50,000 cu. yd. are nearly completed. They have been built, as previously described, by the use of a traveling tower equipped with an elevator, storage bins, and concrete mixer, which moved parallel to the face of the wall and delivered the concrete to dump cars on longitudinal tracks on the tops of the moulds, thus enabling the materials to be handled directly from the cars on which they were delivered, reducing to a minimum the distance from the point of car delivery to the finished work and requiring very small track and storage space in the yard. The wall is made in sections 52 ft. long, containing about 250 cu. yd., one of which has been built in less than seven hours with a force of 60 men. The wall was built in three sections, each of them being constructed in both directions from a center point, and using two moulds moved from end to end alternately as the new work was stripped and floated.

The moulds are somewhat unique in that the sides and ends are made with extremely large panels weighing two or three tons each, and are handled by a locomotive crane. The panels are bolted together by ½-in. horizontal tie rods permanently imbedded in the concrete. Although theoretically stable, the faces and ends of the moulds are braced by inclined shores, and as fast as the concrete is stripped, the mould panels are transferred to the next section, or are temporarily piled up against the wall, as shown in the accompanying photograph.

The transformer station and battery house consist of two duplicate long and narrow buildings separated about 30 ft. on the same center line. Each building is about 40 ft. wide, 200 ft. long and 100 ft. high, with brick walls and steel columns, roof and floor beams. The structural steel in each were built in advance of the walls and was advantageously assembled by fixed derricks. At the commencement of operations a rectangular wooden tower was built in the center of each building with a height a few feet greater than the roof. All of the faces were thoroughly X-braced, and two stiff-leg derricks were seated on top. Each was equipped with a very long boom of sufficient capacity to handle any member of the structural steel work, and the tops of the masts, although not directly connected together, were braced to the tower by stiff legs arranged so as to allow the booms to swing through a horizontal arc of more than 180 deg. The booms were swung by bull wheels operated by hoisting engines seated at ground level. The towers were set to clear the steel framework of the building and as no time was lost in shifting or raising derricks, the arrangement proved very satisfactory and advantageous, and with it the framework was rapidly erected. All of the work is being done under the direction of Mr. W. J. Wilgus, vice-president, and Geo. A. Harwood, terminal engineer. The O'Rourke Engineering & Construction Co. is the general contractor, and the Butler Bros. Construction Co. are the contractors for the transformer station, and for the excavation under Depew Place.



Tall Concrete Retaining Wall East Side of Terminal Yard



Underpinning and Concrete Construction near Tunnel Entrance.

The United States Eight-Hour Law; Its Constitutionality and Construction.

By William B. King, Member of the Bar of the Court of Claims.

The recent decision of the administration at Washington to enforce the Federal eight-hour law makes a discussion of these provisions of present interest to contractors with the United States. State and municipal contracts are also frequently governed by similar statutes.

Constitutionality.—In the year 1883, in a case in which it was asserted that a statute of Louisiana deprived a citizen of rights protected by the Constitution of the United States, a distinguished judge of the Supreme Court of the United States said (Butchers' Union Co. v. Crescent City Co., 111 U. S. 762):

"The right to follow any of the common occupations of life is an inalienable right; it was formulated as such under the phrase 'pursuit of happiness' in the Declaration of Independence, which commenced with the fundamental proposition that 'all men are created equal, that they are endowed by their Creator with certain inalienable rights; that among these are life, liberty and the pursuit of happiness.' This right is a large ingredient in the civil liberty of the citizen."

Thirteen years after that another equally distinguished judge, in another case from the same State, involving the same provision of the Federal Constitution, expressed a little more definitely the meaning of the Constitution in regard to liberty of contract, saying (Allgeyer v. Louisiana, 165 U. S. 591):

"The act done within the limits of the State under the circumstances of this case and for the purpose therein mentioned, we hold a proper act, one which the defendants were at liberty to perform and which the State Legislature had no right to prevent, at least with reference to the Federal Constitution. To deprive the citizen of such a right as herein described without due process of law is illegal. . . . In the privilege of pursuing an ordinary calling or trade and of acquiring, holding and selling property must be embraced the right to make all proper contracts in relation thereto."

Between the dates of these two decisions, on August 1, 1892, Congress passed an act limiting the hours of work upon the Public Works of the United States in the following terms (27 Stat. L. 340):

"Be it enacted, etc., That the service and employment of all laborers and mechanics who are now or may hereafter be employed by the Government of the United States, by the District of Columbia, or by any contractor or sub-contractor upon any of the public works of the United States or of the said District of Columbia, is hereby limited and restricted to eight hours in any one calendar day, and it shall be unlawful for any officer of the United States Government or of the District of Columbia or any such contractor or sub-contractor whose duty it shall be to employ, direct, or control the services of such laborers or mechanics to require or permit any such laborer or mechanic to work more than eight hours in any calendar day except in case of extraordinary emergency."

The second section makes a violation of this act a misdemeanor, and the third section limits its application to contracts thereafter made.

Here is a law which directly interferes with the power of workmen and contractors to make otherwise proper contracts in relation to "following the common occupations of life." Is it not violative of the principles above announced by the highest judicial tribunal? In view of the expressions already quoted, it is no wonder that the constitutionality of this act of Congress has been seriously disputed and that it has been maintained that Congress had no power to enact it. It is the purpose of this paper to show what the courts have decided on this subject. Then some questions of the scope and interpretation of the statute will be discussed.

Up to this time, although the law is fourteen years old, very few prosecutions have been entertained by the courts under it. The officers of the Government charged with the execution of contracts have not burdened themselves with the enforcement of the criminal provision of the laws and prosecuting officers of the Department of Justice have not been informed of violations.

Although a copy of this law or notice of its existence has been inserted in the specifications of many contracts with the United States, it is commonly reported that Government contractors have not been stringently careful to observe its provisions. Certain influential labor organizations have recently called the attention of the President of the United States to its alleged repeated violations and to the non-enforcement of its penalties by the prosecuting officers of the Government. The President's response is characteristic. It is in strict accord with his announcement when Police Commissioner of the City of New York, that he proposed to enforce the highly unpopular liquor laws enacted for that city. He has therefore directed all the executive officers of the United States to inquire into and report to the United States District Attorneys for prosecution all violations of this law. The matter has thus now become one of the greatest interest and importance to the contractors of the United States.

Decisions on Constitutionality.—If the act is unconstitutional, it is because of the provisions of Article V of the Amendments of the Constition, as follows: "Nor shall any person be deprived of life, liberty or property without due process of law." This is a limitation upon the power of the Congress of the United States. The 14th Amendment creates a similar limitation upon the powers of the legislatures of the several States in these words: "Nor shall any State deprive any person of life, liberty or property without due process of law." On account of the identity of terms decisions of the courts interpreting and construing the latter provision may be applied to the former.

The Utah Case.—The first case directly bearing upon the question under discussion was decided by the Supreme Court in 1897. It arose under a statute of the State of Utah declaring that eight hours should constitute a day's work in mines and smelters, and that a violation of this provision should be a misdemeanor. The objection was made by a person accused of violating this law that it was unconstitutional because it deprived both mine owner and workman of their liberty of contract, and the miner of his control of his property in his own labor. The Supreme Court laid down the general rule in accordance with the decisions already quoted, as follows (Holden v. Hardy, 169 U. S. 391):

"As the possession of property, of which a person cannot be deprived, doubtless implies that such property may be acquired, it is safe to say that a State law which undertakes to deprive any class of persons of the general power to acquire property would also be obnoxious to the same provision. Indeed, we may go a step further, and say that, as property can only be legally acquired as between living persons by contract, a general prohibition against entering into contracts with respect to property, or having as their object the acquisition of property, would be equally invalid."

This doctrine, had it been found applicable to the case then before the court, would have resulted in the Utah statute being declared unconstitutional. But another principle was found applicable, known as the police power of the State; that is, the right of the State by general laws to protect the health and property of its citizens. Work in mines for prolonged periods is unhealthful, and the Supreme Court within the State had a right, without violating the prohibition of the 14th Amendment, to regulate the hours of underground work. Numerous statutes of States regulating mining and other unhealthful occupations and governing the hours of labor of children and others needing the protection of the law were cited to support this view, the court saying (pp. 395-6):

"Upon the principles above stated, we think the act in question may be sustained as a valid exercise of the police power of the State. The enactment does not profess to limit the hours of all workmen, but merely those who are employed in underground mines, or in the smelting, reduction or refining of ores or metals. These employments, when too long pursued, the Legislature has judged to be detrimental to the health of the employees, and, so long as there are reasonable grounds for believing that this is so, its decision upon this subject cannot be reviewed by the Federal courts.

"While the general experience of mankind may justify us in believing that men may engage in ordinary employments more than eight hours per day without injury to their health, it does not follow that labor for the same length of time is inocuous when carried on beneath the surface of the earth, where the operative is deprived of fresh air and sunlight, and is frequently subjected to foul atmosphere and a very high temperature, or to the influence of noxious gases, generated by the processes of refining or smelting."

Two judges dissented from this view and thought even this law unconstitutional.

In the light of this decision we must conclude that any eight-hour law that is actually a health regulation is constitutional. The United States eight-hour law now under discussion is not that sort of a law, and we must therefore look further to decide its constitutionality.

The New York Case.—A later case arising under a New York statute needs consideration next. The New York Legislature passed a law that no employees in bakeries should be required or permitted to work longer than ten hours a day. The same objections to this law were made in this case as in the Utah case, that the right to contract in regard to one's labor was a right of personal property and liberty protected by the provisions of the Constitution. The Judge of the Supreme Court delivering the opinion fully sustained this principle, saying (Lochner v. New York, 198 U. S. 53):

"The general right to make a contract in relation to his business is part of the liberty of the individual protected by the 14th Amendment of the Federal Constitution. Allgeyer v. Louisiana, 165 U. S. 578. Under that provision no State can deprive any person of life, liberty or property without due process of law. The right to purchase or to sell labor is part of the liberty protected by this amendment, unless there are circumstances which exclude the right."

The opinion then discussed the right of the Legislature to regulate pursuits affecting the health of citizens and, quoted the decision of the Supreme Court in the Utah case just referred to. The discrimination between a constitutional health regulation and an unconstitutional invasion of personal liberty was declared in the following language (p. 56):

"In every case that comes before the court, therefore, where legislation of this character is concerned and where the protection of the Federal Constitution is sought, the question necessarily arises: Is this a fair, reasonable and appropriate exercise of the police power of the State, or is it an unreasonable, unnecessary and arbitrary interference with the right of the individual to his personal liberty or to enter into those contracts in relation to labor which may seem to him appropriate or necessary for the support of himself and his family? Of course the liberty of contract relating to labor includes both parties to it. The one has as much right to purchase as the other to sell labor."

If not sustainable as a health regulation, the court was very clear that the law was not constitutional, saying (p. 57):

"The question whether this act is valid as a labor law, pure and simple, may be dismissed in a few words. There is no reasonable ground for interfering with the liberty of person or the right of free contract, by determining the hours of labor, in the occupation of a baker. There is no contention that bakers as a class are not equal in intelligence and capacity to men in other trades or manual occupations, or that they are not able to assert their rights and care for themselves without the protecting arm of the State, interfering with their independence of judgment and of action. They are in no sense wards of the State. Viewed in the light of a purely labor law, with no reference whatever to the question of health, we think that a law like the one before us involves neither the safety, the morals nor the welfare of the public, and that the interest of the public is not in the slightest degree affected by such an act."

The learned judge then submitted the following as the momentous question to be decided (p. 57):

"It is a question of which of two powers or rights shall prevail—the power of the State to legislate or the right of the individual to liberty of person and freedom of contract."

Statutes limiting the hours of labor were condemned in the following severe language (pp. 59, 61, 64):

"No trade, no occupation, no mode of earning one's living, could escape this all-pervading power, and the acts of the legislature in limiting the hours of labor in all employments would be valid, although such limitation might seriously cripple the ability of the laborer to support himself and his family.

"Statutes of the nature of that under review, limiting the hours in which grown and intelligent men may labor to earn their living, are mere meddlesome interferences with the rights of the individual, and they are not saved from condemnation by the claim that they are passed in the exercise of the police power and upon the subject of the health of the individual whose rights are interfered with, unless there be some fair ground, reasonable in and of itself, to say that there is material danger to the public health or to the health of the employees, if the hours of labor are not curtailed. If this be not clearly the case the individuals, whose rights are thus made the subject of legislative interference, are under the protection of the Federal Constitution regarding the liberty of contract as well as of person; and the legislature of the State has no power to limit their right as proposed in this statute."

The ultimate conclusion of the court was that the statute was wholly invalid because not a health regulation, but an unwarranted interference with personal liberty.

"It is manifest to us that the limitation of the hours of labor as provided for in this section of the statute under which the indictment was found, and the plaintiff in error convicted, has no such direct relation to and no such substantial effect upon the health of the employee, as to justify us in regarding the section as really a health law. It seems to us that the real object and purpose were simply to regulate the hours of labor between the master and his employees (all being men, sui juris), in a private business, not dangerous in any degree to morals or in any real and substantial degree to the health of the employees. Under such circumstances the freedom of master and employee to contract with each other in relation to their employment, and in defining the same, cannot be prohibited, or interfered with, without violating the Federal Constitution."

This decision was by a divided court of five to four. Notwithstanding this narrow majority, the decision stands as the law of the land.

The dissenting judges did not dispute the general doctrine that except as a regulation in the interest of the health of the community, laws forbidding work of citizens of full age could not be sustained, but they considered this particular law sustainable as a health regulation.

What, then, is the effect of this decision upon the constitutionality of the law now under consideration? It is clear that if this statute prohibited over eight hours' work under private contracts it would be unconstitutional.

But this law does not purport to regulate contracts between individuals; it confines itself entirely to contracts to which the United States is a party. It limits the hours of labor upon public works of the United States. Congress controls the Treasury of the United States and its expenditures. Can Congress say that a day's work under the contracts made by the Government in its business capacity shall not exceed eight hours?

Even if private individuals may not be interfered with in contracting between themselves as to their labor, may not Congress yet enforce upon the United States in making its contracts any rule which seems fit to Congress without violating any constitutional right?

The Kansas Case.—A case involving this very question has come before the Supreme Court. The State of Kansas passed a law similar to the United States eight-hour law, declaring that eight hours shall constitute a day's work for laborers, workmen, mechanics and other persons employed by the State or any county or municipality of the State, and made it a penal offense to require or permit a laborer to work over eight hours on a public work.

The city of Kansas made a contract with one Atkin to improve a street. He required over eight hours' work from his employees and was prosecuted for it.

The contractor defended on the ground that the statute violated the Constitution of the United States, depriving both him and the laborer of liberty and property without due process of law. He cited the constitutional definitions already quoted here. The Supreme Court of the United States had then decided the Utah case, holding the miner's eight-hour law constitutional, but not the New York case holding the baker's ten-hour law unconstitutional.

In deciding the Kansas case the Supreme Court declared that a municipal corporation of a State was an instrument of the State itself in carrying out its government purposes and the contracts of the corporation were under the complete control of the State. It held that the State could regulate the conditions of such contracts and determine whether laborers on public works could be employed more than eight hours a day. The opinion of the court was very positively expressed in the following language (Atkin v. Kansas, 191 U. S. 222):

"We can imagine no possible ground to dispute the power of the State to declare that no one undertaking work for it or for one of its municipal agencies, should permit or require an employee on such work to labor in excess of eight hours each day, and to inflict punishment upon those who are embraced by such regulations and yet disregard them. It cannot be deemed a part of the liberty of any contractor that he be allowed to do public work in any mode he may choose to adopt, without regard to the wishes of the State. On the contrary, it belongs to the State, as the guardian and trustee for its people, and having control of its affairs, to prescribe the conditions upon which it will permit public work to be done on its behalf, or on behalf of its municipalities. No court has authority to review its action in that respect. Regulations on this subject suggest only considerations of public policy. And with such considerations the courts have no concern.

"If it be contended to be the right of everyone to dispose of his labor upon such terms as he deems best—as undoubtedly it is—and that to make it a criminal offense for a contractor for public work to permit or require his employee to perform labor upon that work in excess of eight hours each day, is in derogation of the liberty both of employees and employer, it is sufficient to answer that no employee is entitled, of absolute right and as a part of his liberty, to perform labor for the State; and no contractor for public work can excuse a violation of his agreement with the State by doing that which the statute under which he proceeds distinctly and lawfully forbids him to do."

The court was reminded in argument that there was danger to the citizen in being deprived of his right to work as he pleased, but answered that contention in the following positive manner (p. 223):

"We are reminded by counsel that it is the solemn duty of the courts in cases before them to guard the constitutional rights of the citizen against merely arbitrary power. That is unquestionably true. But it is equally true—indeed, the public interests imperatively demand—that legislative enactments should be recognized and enforced by the courts as embodying the will of the people, unless they are plainly and palpably, beyond all question, in violation of the fundamental law of the Constitution. It cannot be affirmed of the statute of Kansas that it is plainly inconsistent with that instrument; indeed its constitutionality is beyond all question."

The final conclusion of the court was stated in the following broad form (p. 224):

"We rest our decision upon the broad ground that the work being of a public character, absolutely under the control of the State and its municipal agents acting by its authority, it is for the State to prescribe the conditions under which it will permit work of that kind to be done. Its action touching such a matter is final so long as it does not, by its regulations, infringe the personal rights of others; and that has not been done."

Three judges out of nine dissented from this decision and declared the law unconstitutional. Two of them had already dissented in the Utah case and would have held that law unconstitutional, and these same judges afterwards joined with the majority of the court in declaring the New York statute unconstitutional, one of them delivering the opinion of the court. It is thus seen that there is a minority of the Supreme Court who believe that all statutes regulating hours of labor in any way are outside the powers of Congress or of State legislatures.

Nevertheless the decision of the Supreme Court in the Kansas case just cited is now the law of the land. The Kansas statute is substantially the same as the United States statute. The provision of the Constitution forbidding the violation of the liberty of the citizen by a State is the same as the like provision in regard to the United States. Therefore no constitutional guarantee can be invoked against the Federal statute which had not already been invoked against the statute of Kansas already declared constitutional. The conclusion must therefore be reached that, unless the Supreme Court of the United States reverses its decision in that case, contractors doing work for the United States must regard the eight-hour law as a constitutional and valid act of Congress, and its penalties as legally enforcible by the courts.

It is true that the Supreme Court has been known to reverse its own rulings. Minorities at one time have become majorities at others, yet the instances are rare, and a change of ruling in this respect cannot be anticipated.

(To be continued.)

AN ICE-BREAKING STEAMER, recently built in England for the Canadian Government, will be utilized in keeping the St. Lawrence River open for navigation during the winter season. The vessel has a length of 172 ft., a molded beam of 32 ft. and a normal draft of 12 ft., with a displacement of 1,055 tons. The bow is of the Canadian type formed to mount and break through green ice and for going through pack ice. A broad belt of heavy plating, extending considerably above and below the water line, is fitted fore and aft, and the cross-sectional form of the hull is designed to resist the lateral pressure of the ice. Intermediate channels forming double framing have been introduced to further counteract thwartship pressure. Forward where the vessel first strikes ice these additional members extend from the keel to the main deck, while aft they are introduced between the bilge and main decks. The side plating is also increased in thickness from the stem to a point well aft of midships. The hull is divided in six water-tight compartments, with a double bottom extending from forward to after-peak bulkheads. The compartments forward and aft of the bulkheads are arranged as deep ballast tanks, into or from which water can be pumped to alter quickly the trim to assist the vessel in riding over ice, when the latter is broken by the superimposed weight. The vessel will have two sets of propellor screws, a light set for ordinary summer service and the other specially designed for ice work. These propellors are driven by two sets of inverted, vertical, direct-acting, triple-expansion condensing engines capable of developing 2,300-h.-p. The steamer is also equipped, according to Engineering, for surveying and salvage work, an efficient arrangement of towing gear having been provided at the same time.

Some Characteristics of Coal as Affecting Performance with Steam Boilers.

A paper read by Mr. W. L. Abbott before the Western Society of Engineers.

The capacity and efficiency obtained with a steam boiler is the result of many influences more or less variable in character, and for the purpose of studying some of these influences, certain experiments were conducted in which coal screenings were used, the results of which are presented in this paper.

The apparatus employed in the researches to be considered consisted of two Babcock & Wilcox boilers, one with a tube surface 14 tubes high, and 18 wide, and having approximately 5,000 sq. ft. of heating surface. It was fitted with a chain grate stoker, 75 sq. ft. in area, which discharged the gases of the fire from under an ignition arch 5 ft. long, immediately among the tubes of the boiler. The boiler was also fitted with a Babcock & Wilcox superheater having an approximate area of surface of 1,000 sq. ft. The other apparatus employed in one of the series of tests differed only in sizes of its boiler which was 12 tubes high and 16 wide, contained 4,000 sq. ft. of heating surface; it was provided with a superheater and had a chain grate stoker 66 sq. ft. in area.

The experiments were for the purpose of studying the effect on capacity and efficiency due to coal of different sizes; the influence of ash in coal on capacity and efficiency; the effect of variation in size of coal screenings, and the results of different thicknesses of fire.

The experiments illustrated by Diagram 1 consisted in the use of coal separated into various sizes by means of screens having the following square openings: 0.25, 0.50, 0.75, 1.0 and 1.25 in. The coal was all from one lot, so that the different portions resulting from the screening process were necessarily the "same kind of coal," except that some portions were uniformly larger and others smaller, and that the smallest, on account of its size, was higher in ash. As shown by the curves of efficiency and capacity in the diagram, five tests were made, each with a different size of coal. In all other respects, however, everything was equal; thus influencing conditions, except that due to size of coal, were constant. In this way, relative values for the feature studied were obtained as shown by the diagram.

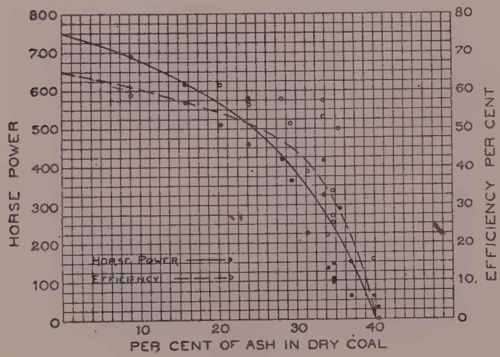


Diagram 2.

The percentage of ash in the dry coal of the various sizes was as follows:

	Square screens.		Ash in Dry coal.
	Through.	Over.	
Size of coal, in....	1.25	1.00	13.7
" " "....	1.00	0.75	14.0
" " "....	0.75	0.50	15.6
" " "....	0.50	0.25	20.8
" " "....	0.25	0.00	30.8

The high per cent. in the smallest size is not due to ash in the coal itself, but to the fact that all of the fine sized foreign matter separated from larger coal, or which comes from roof or floor of the mine, naturally finds its way into this smaller coal.

Influence of Ash in Coal on Capacity and Efficiency.—Diagram 2 gives results of eighteen tests made to determine the effect of varying quantities of ash associated with coal. One result of its presence is to reduce the heating power, owing to displacement of combustible matter. Therefore, in this connection, ash may be considered as a dilutant, and if this was the only result of its presence, it would have no effect on heat efficiency secured through a boiler. A proportionately less amount of water would be evaporated by a pound of such mixture of ash and coal, of course, but efficiency would not be affected. If, however, ash acts in some other way as well, such as an obstruction to the combustion process, the effect of its presence is doubly harmful.

To insure that the result would not be affected by any influence other than that of the ash, special coal was used which came from the No. 7 seam, north of Marion in Williamson County, Ill. It was prepared in a Stewart washer and is known to the trade as No. 4 washed coal, a size made by passing over a screen having ¼-in. round openings, and through one having similar ½-in. openings. Its composition is represented in Table I.

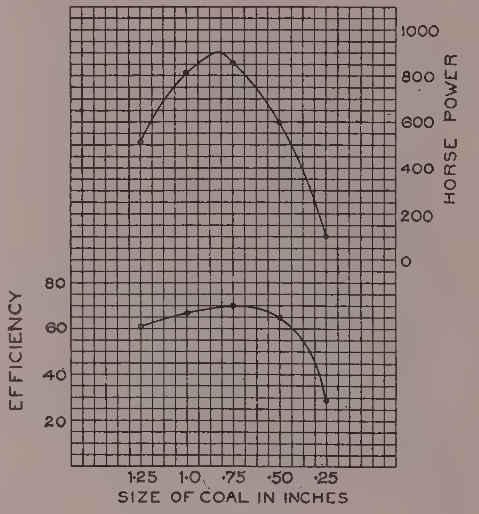


Diagram 1.

Table I.
Composition of Coal.

Moist coal:	
Moisture	7.48
Ash	8.23
B. T. U.	12,191
Dry coal:	
Ash	8.90
B. T. U.	13,176
Pure coal:	
B. T. U.	14,463

The test indicated by the two points showing highest efficiency and capacity was made with coal just as it arrived, or in other words, was of the composition shown by the analysis. Beginning with the test of the second day, a quantity of refuse from the stoker ash pits was added to the coal to be used. This refuse was first weighed and the large pieces broken up, after which it was thoroughly mixed with the coal in the required proportion and increasing amounts were added in each test which followed. This fuel composition was, of course, weighed as used and a sample of it selected for analysis in the regular manner.

It appears from the diagram that useful effect from the fuel drops to zero with 40 per cent. of ash, notwithstanding the fact that the other 60 per cent. of the composition was pure coal. The fact should be emphasized, that although over half of the composition fed to the fire was fuel, it burned without producing any useful effect, for which there are two reasons; one, that on account of obstructed air supply through the fuel bed, incomplete combustion and escaping hydrocarbons carried away a portion of the heat, because the gases passed immediately among the tubes of the boiler. The other is, that owing to the presence of an excess of ash, the percentage of fuel on the rear portion of the grate is greatly reduced. On this account a larger proportion of the air passing through the fuel bed does not combine with the fuel, but enters the furnace as free air. As the prime function of a furnace is to heat the gases passing through it, any increase in the amount of air entering the furnace without a corresponding increase in the amount of fuel burned must result in a lowering of the furnace temperature.

This lowering of temperature, besides making a long, smoky flame, which reaches up among the boiler tubes and is there chilled to below the burning point, also reacts on the fuel bed, reducing the rate of combustion and still further increasing the adulteration of the furnace gases with free air. When the temperature of the furnace has been thus reduced to about 600° Fahr. the boiler is unable to absorb any more heat than is necessary to make up for radiation losses.

It will be observed that the points on the diagram do not fall in symmetrical order. This is particularly true of ash percentages of about 34, which may be explained by the refuse used in these tests being probably of a more fusible character than with others. These tests with the ash composition were made with the smaller boiler above mentioned.

Effect of Variation in Size of Coal Screenings.—In Illinois and Indiana coal not sold as mine run is separated largely as lump and screenings, and such screenings furnish about 90 per cent. of the stoker fuel used in Illinois.

Diagrams 3 and 4 illustrated the result of sixty-two tests. With each the size of coal as measured by screens with square openings ranging in dimensions from 0.25 to 1.50 ins., advancing by 0.25 in., and the average sizes of coal as shown at the base of the diagrams, were calculated from sizing tests made with these screens, and represent the dimension in fractions of an inch of openings in a screen which would allow one-half of the coal to pass through and the other half to go over the screen, and it is this that is designated as its average size.

Diagram 3 shows the effect produced on horsepower output owing to this variation in size of the coal, and Diagram 4 illustrates the resulting efficiency from the same cause and for the same tests.

The curves for both efficiency and capacity drop midway between the tests with both small and

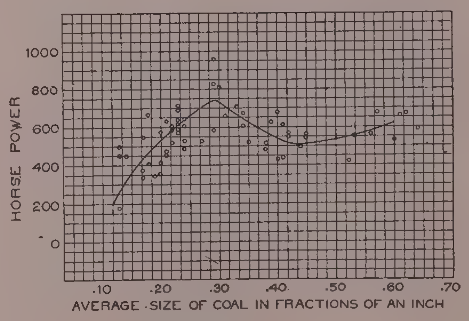


Diagram 3.

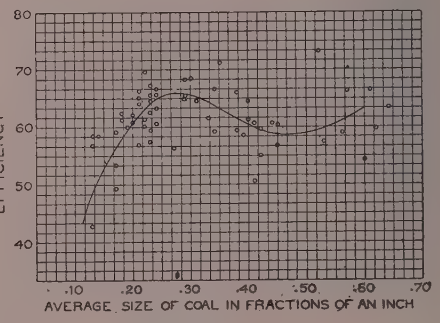


Diagram 4.

large coal. This is a peculiarity which may be explained as follows: Performance becomes better as the size of coal increases, until a point is reached when the quantity of large pieces becomes so great that there is not enough fine material to properly close the interstices between, with the result that performance drops off, due to excess of air, until a condition is reached when all of the pieces of fuel approach uniformity, when owing to greater agreement in size, they fit together better, and in a measure produce a homogeneous mass similar to that secured by the fine dust filling the spaces in the fuel bed in the first case.

Table III.

PERCENT OF ASH IN DRY COAL

PERCENTAGE OF COAL THROUGH 1/4 INCH ROUND SCREEN	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
31	100	99	98	96	95	94	92	91	89	88	86	84	82	80	78	76	73	70	67	63	58	53	48	42	35	28	20	10	0
32	98	97	96	94	93	92	90	89	87	86	84	82	80	78	76	74	71	68	65	61	56	51	46	40	33	26	18	8	
33	96	95	94	92	91	90	88	87	85	84	82	80	78	76	74	72	69	66	63	59	54	49	44	38	31	24	16	6	
34	94	93	92	90	89	88	86	85	83	82	80	78	76	74	72	70	67	64	61	57	52	47	42	36	29	22	14	4	
35	93	92	91	89	88	87	85	84	82	81	79	77	75	73	71	69	66	63	60	56	51	46	41	35	28	21	13	3	
36	91	90	89	87	86	85	83	82	80	79	77	75	73	71	69	67	64	61	58	54	49	44	39	33	26	19	11	1	
37	90	89	88	86	85	84	82	81	79	78	76	74	72	70	68	66	63	60	57	53	48	43	38	32	25	18	10		
38	88	87	86	84	83	82	80	79	77	76	74	72	70	68	66	64	61	58	55	51	46	41	36	30	23	16	8		
39	87	86	85	83	82	81	79	78	76	75	73	71	69	67	65	63	60	57	54	50	45	40	35	29	22	15	7		
40	85	84	83	81	80	79	77	76	74	73	71	69	67	65	63	61	58	55	52	48	43	38	33	27	20	13	5		
41	83	82	81	79	78	77	75	74	72	71	69	67	65	63	61	59	56	53	50	46	41	36	31	25	18	11	3		
42	82	81	80	78	77	76	74	73	71	70	68	66	64	62	60	58	55	52	49	45	40	35	30	24	17	10	2		
43	80	79	78	76	75	74	72	71	69	68	66	64	62	60	58	56	53	50	47	43	38	33	28	22	15	8			
44	78	77	76	74	73	72	70	69	67	66	64	62	60	58	56	54	51	48	45	41	36	31	26	20	13	6			
45	77	76	75	73	72	71	69	68	66	65	63	61	59	57	55	53	50	47	44	40	35	30	25	19	12	5			
46	75	74	73	71	70	69	67	66	64	63	61	59	57	55	53	51	48	45	42	38	33	28	23	17	10	3			
47	74	73	72	70	69	68	66	65	63	62	60	58	56	54	52	50	47	44	41	37	32	27	22	16	9	2			
48	72	71	70	68	67	66	64	63	61	60	58	56	54	52	50	48	45	42	39	35	30	25	20	14	7				
49	71	70	69	67	66	65	63	62	60	59	57	55	53	51	49	47	44	41	38	34	29	24	19	13	6				
50	69	68	67	65	64	63	61	60	58	57	55	53	51	49	47	45	42	39	36	32	27	22	17	11	4				
51	67	66	65	63	62	61	59	58	56	55	53	51	49	47	45	43	40	37	34	30	25	20	15	9	2				
52	66	65	64	62	61	60	58	57	55	54	52	50	48	46	44	42	39	36	33	29	24	19	14	8	1				
53	64	63	62	60	59	58	56	55	53	52	50	48	46	44	42	40	37	34	31	27	22	17	12	6					
54	62	61	60	58	57	56	54	53	51	50	48	46	44	42	40	38	35	32	29	25	20	15	10	4					
55	61	60	59	57	56	55	53	52	50	49	47	45	43	41	39	37	34	31	28	24	19	14	9	3					
56	59	58	57	55	54	53	51	50	48	47	45	43	41	39	37	35	32	29	26	22	17	12	7	1					
57	58	57	56	54	53	52	50	49	47	46	44	42	40	38	36	34	31	28	25	21	16	11	6						
58	56	55	54	52	51	50	48	47	45	44	42	40	38	36	34	32	29	26	23	19	14	9	4						
59	54	53	52	50	49	48	46	45	43	42	40	38	36	34	32	30	27	24	21	17	12	7	2						
60	53	52	51	49	48	47	45	44	42	41	39	37	35	33	31	29	26	23	20	16	11	6	1						
61	51	50	49	47	46	45	43	42	40	39	37	35	33	31	29	27	24	21	18	14	9	4							
62	49	48	47	45	44	43	41	40	38	37	35	33	31	29	27	25	22	19	16	12	7	2							
63	48	47	46	44	43	42	40	39	37	36	34	32	30	28	26	24	21	18	15	11	6	1							
64	46	45	44	42	41	40	38	37	35	34	32	30	28	26	24	22	19	16	13	9	4								
65	45	44	43	41	40	39	37	36	34	33	31	29	27	25	23	21	18	15	12	8	3								
66	43	42	41	39	38	37	35	34	32	31	29	27	25	23	21	19	16	13	10	6	1								
67	41	40	39	37	36	35	33	32	30	29	27	25	23	21	19	17	14	11	8	4									
68	40	39	38	36	35	34	32	31	29	28	26	24	22	20	18	16	13	10	7	3									
69	38	37	36	34	33	32	30	29	27	26	24	22	20	18	16	14	11	8	5	1									
70	37	36	35	33	32	31	29	28	26	25	23	21	19	17	15	13	10	7	4										
71	35	34	33	31	30	29	27	26	24	23	21	19	17	15	13	11	8	5	2										
72	33	32	31	29	28	27	25	24	22	21	19	17	15	13	11	9	6	3											
73	32	31	30	28	27	26	24	23	21	20	18	16	14	12	10	8	5	2											
74	30	29	28	26	25	24	22	21	19	18	16	14	12	10	8	6	3												
75	28	27	26	24	23	22	20	19	17	16	14	12	10	8	6	4	1												
76	27	26	25	23	22	21	19	18	16	15	13	11	9	7	5	3													
77	25	24	23	21	20	19	17	16	14	13	11	9	7	5	3	1													
78	24	23	22	20	19	18	16	15	13	12	10	8	6	4	2														
79	22	21	20	18	17	16	14	13	11	10	8	6	4	2															
80	20	19	18	16	15	14	12	11	9	8	6	4	2																
81	19	18	17	15	14	13	11	10	8	7	5	3	1																
82	17	16	15	13	12	11	9	8	6	5	3	1																	
83	16	15	14	12	11	10	8	7	5	4	2																		
84	14	13	12	10	9	8	6	5	3	2																			
85	12	11	10	8	7	6	4	3	1																				
86	11	10	9	7	6	5	3	2																					
87	9	8	7	5	4	3	1																						
88	7	6	5	3	2	1																							
89	6	5	4	2	1																								
90	4	3	2																										
91	3	2	1																										
92	1																												
93	0																												

COAL VALUES FOR SCREENINGS

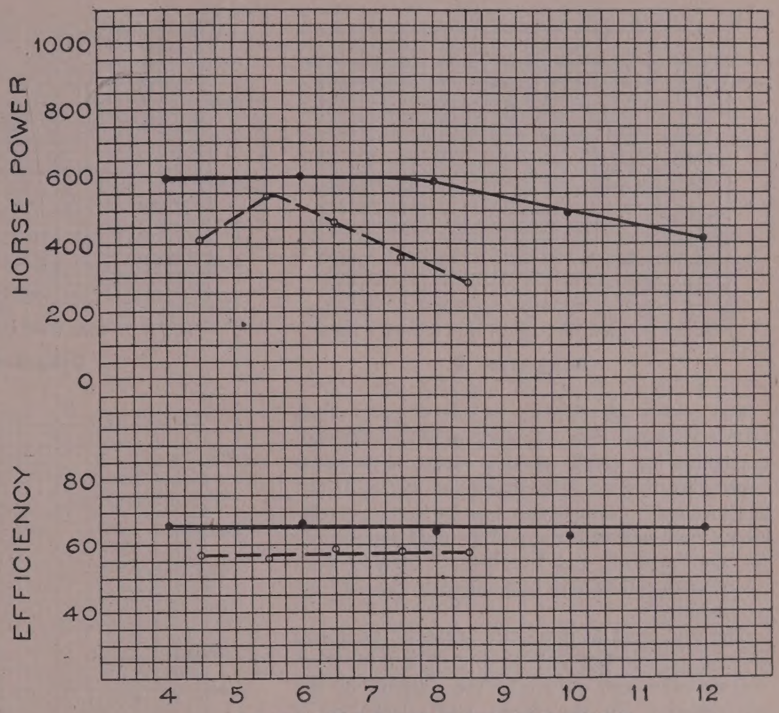


Diagram 5.

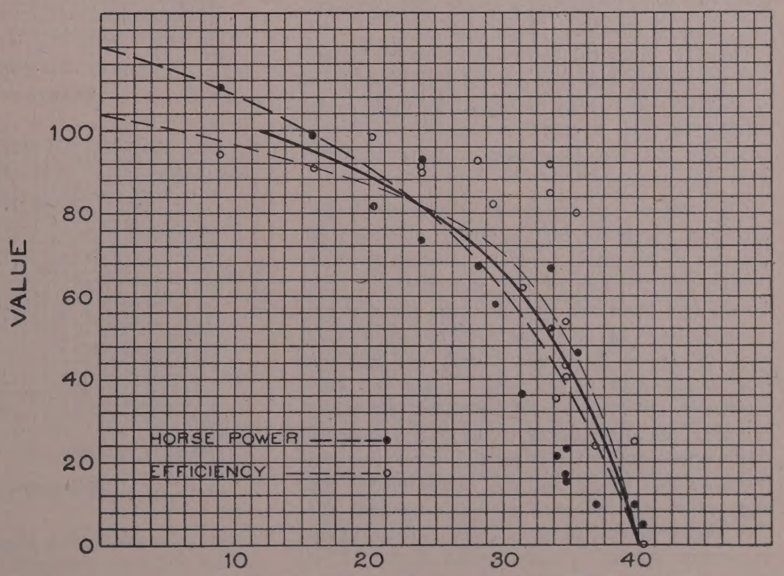


Diagram 6.

The presence of fine dust in excess is a great and important source of trouble. Referring to Diagram 1, coal through an 0.25 in. square screen produced only 108 h.-p., yet a size of fuel known in Illinois as No. 5 washed coal, which will pass through an 0.25 in. round hole (a smaller aperture than the square opening) will produce as high as 600 h.-p. under the same boiler. It is true that the lower ash content of the washed coal has a considerable influence, but this is offset by the larger size of the square screen as against the round one.

To arrive at a better understanding of the physical make-up of these two characters of fuel, tests were made of the dust of each, using that quantity which would pass through a 20-mesh screen, with the results shown in Table II.

The quantity of the extremely fine dust through the 100-mesh screen is shown to be almost three times as much in the unwashed as with the washed coal. The third line of the table is an average from five tests taken from different lots of screenings, and it shows an approximate agreement with the quantities from the dust through the ¼-in. square screen, from which it follows that the presence of the fine dust has an enormous influence on the burning of the fuel.

Table II.

Quantity and size of coal dust below 20-mesh screen.

Dust sample.	Through 20 and over 40.	Through 40 and over 60.	Through 60 and over 80.	Through 80 and over 100	Through 100
	Percentage of different sizes.				
No. 5 washed...	63.36	16.78	6.51	2.93	10.42
Duff through ¼-in. sq. screen..	46.10	13.87	8.18	3.84	28.01
Avg. of five tests from ordinary screenings	48.50	13.78	7.57	4.38	25.74

Result of Different Thicknesses of Fire.—An excess of air accompanies a thin fire, and because of it, efficiency produced through the boiler is affected. On the other hand, a thick fire reduces the excess of air, but increases the volume of hydrocarbon gases which leave the surface, or in other words, makes more smoke. If a furnace is located between the boiler and stoker, these gases will be burned, otherwise they will largely escape among the tubes of the boiler as they did in this case. Therefore, under these conditions, a thin fire increases the loss due to excess of air, but decreases that due to smoke and incomplete combustion. On the other hand, a thick fire reduces the excess of air, but increases the smoke and escaping combustible gas, and so the best thickness of fire may be a matter of importance. With this type of boiler of a height of nine tubes when served with chain grate stokers discharging immediately among the tubes, it is always most economical to produce as large a volume of smoke as possible with the coal being used. With boilers of fourteen tubes in height, the conditions are different, because such boilers are more efficient.

With an ideal boiler the final temperature would be the same as the atmosphere, therefore an unlimited excess of air could be used without causing heat loss. No practical boiler can, of course, be an ideal one, but the Babcock & Wilcox type of 14 tubes high approaches much nearer to it than does one of 9 high, and for that reason is more efficient, and in this connection is quite unique as Diagram 5 will show.

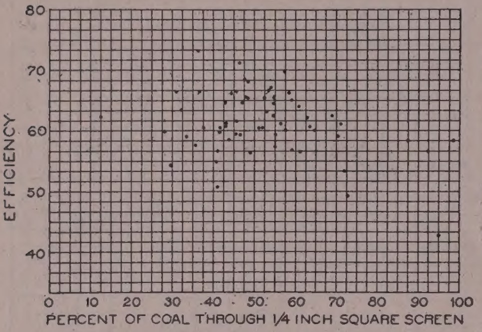


Diagram 8.

The curves of efficiency in this diagram illustrate a constant heat efficiency produced through the boiler for a full working range in thickness of fire, insuring not only maximum excess of air, but incomplete combustion loss as well, yet efficiency remained uniform, and the only opportunity for the "skillful" and "intelligent" fireman is in selecting that thickness best suited to capacity requirements.

The coal used in these two series of tests was very uniform in size and ash content, and for these reasons was well suited to the purpose of the experiments. In the series with thickness of fire, from 4.5 to 8.5 in., what is known as No. 5 washed coal was used, a size which passes through a screen having round openings 0.25 in. diameter. With the other series and a larger range in thickness, washed screenings were employed.

Table III gives values in one figure for screenings containing different percentages of ash, and of variation in size as measured by that portion passing through a 0.25 in. round screen. The following detailed statement explains how this table was prepared.

The value of coal screenings is affected by four variables, which are heating power, moisture, ash and size of the pieces of coal. Heating power in Illinois and Indiana of the pure coal—in other words, free from ash and moisture, the real coal—ranges from 13,800 as the minimum to a maximum of 14,500 B.t.u. per pound, and moisture from about 9 to 14 per cent. These two characteristics, however, are of minimum importance, as either can affect the result by only a comparatively small amount. With the other two features, amount of ash and size of the pieces, each may exert an influence of such moment that they cause the fuel to be valueless. Thus, in fuel inspection service it may be necessary to test only the latter characteristics, therefore Table III is based on variation in percentage of ash and on size of the coal, moisture and heating power being assumed as constant.

The fuel in service under a boiler produces two results, one of efficiency and the other of capacity, and capacity, or in other words, quantity of steam produced, is a matter of great importance. Therefore, if these two effects may be averaged and treated as a single value, the problem is much simplified.

Inspection of Diagrams 3 and 4 shows that resulting capacity and efficiency are approximately the same, and that the condition of fuel which results in a high efficiency also produces large capacity. This makes it possible to assign two values to the fuel, one applying to ash content, the other to its size, each of these values embracing efficiency and capacity as a unit.

In placing the effect due to ash in shape for use in preparation of Table III, Diagram 6, which is a reproduction of Diagram 2, has a heavy curve, drawn midway between those of efficiency and capacity. This average curve represents the value of the fuel as far as ash is concerned, which appears to be 100 per cent., with 12 per cent. of ash in the dry screenings, and according to this, value could be greater than 100 per cent., but 12 per cent. represents an average minimum ash content for coal screenings in Illinois and Indiana at the present time, therefore such fuel is the best obtainable, and for this reason may have a value of 100 per cent. assigned to it.

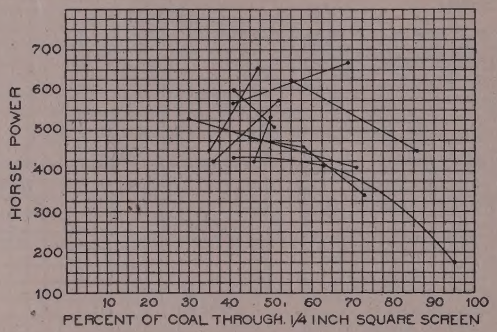


Diagram 9.

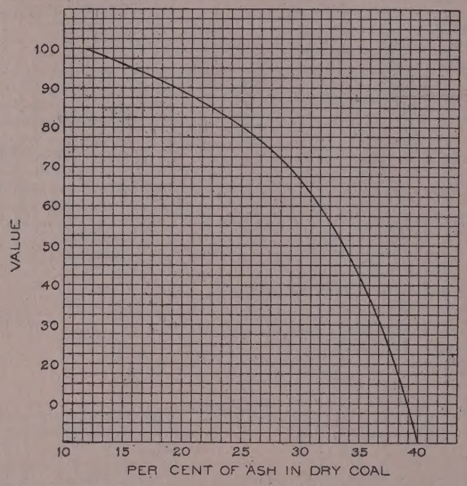


Diagram 7.

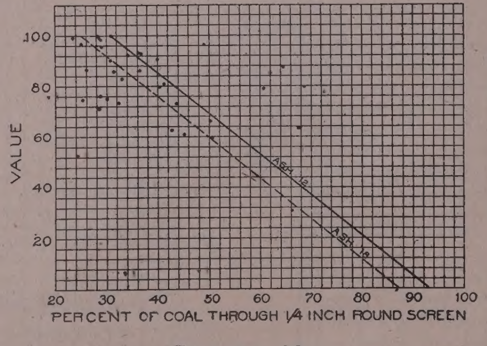


Diagram 10.

Thus Diagram 7 contains a curve showing value taken from Diagram 6, and without the complication of curves and points in the latter, and ash values were taken directly from it for use in the compilation of Table III.

The feature of size is a more difficult problem than that of ash, as the following will show. After the tests represented in Diagrams 3 and 4 (62 in number) were finished, Diagram 8 was plotted, using percentages of coal through a 0.25 in. square screen. The diagram for efficiency only is shown, because that for capacity gave no different result. It is apparent that the arrangement of points fails to show any harmful effect due to presence of excessive quantity of fine dust. The fuel used in these 62 tests was ordinary screenings, containing varying amounts of ash, and to ascertain if this variable ash content could be the cause of the failure of Diagram 8 to show harmful effect of fine dust, individual tests were used in the plotting of Diagram 9, the ash content for the tests shown by any one of the curves being constant, while the size as represented by the percentage through the 0.25 in. square screen varied. The result of this analysis made it appear that the presence of finer sizes was sometimes harmful, and in other cases beneficial. The scheme of average size was then adopted and employed, with the result shown by Diagrams 3 and 4, described in the first division of this paper, and as a check on the conclusions of these two diagrams, Diagram 10 was plotted, based on percentages through a 0.5 in. screen. With 1.25 in. screenings, this size is nearer to the general average than that of 0.25 in., and it is apparent that a curve may be drawn through the points which will show a falling off in efficiency or capacity with increase in quantity of fuel through the 0.5 in. screen which helps to corroborate the conclusions of Diagrams 3 and 4.

In coal inspection service, it is quite essential that the tests be simple and few in number, but determination of the average size requires that several screens be employed, involving a large amount of work, as well as difficult calculation, and for this reason there is great advantage in using but one screen. The 0.25-in. size having received more or less favorable consideration, in working out a scheme for its use in connection with Table III, all of the tests which showed a capacity below 575 h.-p. were taken. With these data Diagram 11 was prepared. The average ash in the dry coal for these tests was 18 per cent. A curve representing values for this ash content, and also for standard ash of 12 per cent. being drawn, the latter curve gave values for use in Table III. The quantities of coal were transposed from that through the 0.25-in. square to a 0.25-in. round screen. Thus the final result for ash shown by Diagram 7 and that for size by Diagram 11, furnished data used for calculating the final combined values in Table III, from which it appears that screenings, having 12 per cent. of ash or less, and of a size that no more than 31 per cent. will pass a 0.25-in. round screen may be considered of 100 per cent. value, or in other words, sufficiently good for the purpose.

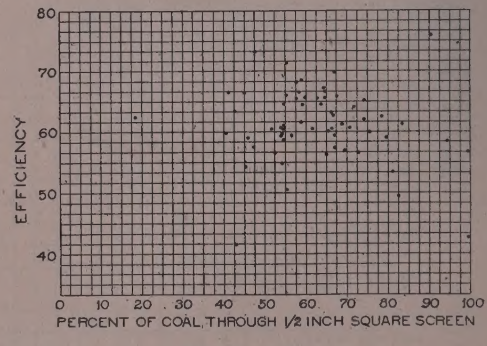


Diagram 11.

Basing conclusions on the measurement given by any one screen is arbitrary, as four points in Diagram 11 indicates, therefore, while Table III may be depended on to identify all of the coal containing an excess amount of fine sizes, it will, in a few cases, condemn satisfactory fuel.

This paper does not presume to lay down the ultimate laws by which fine coals may be graded in value, but rather to point out the fact that such laws, although at present obscure, do exist, and that our conclusions drawn from numerous tests are as herein indicated.

During the year 1905 there was produced in

Illinois and Indiana about 50,000,000 tons of coal, 48 per cent. of which was 1¼ in. screenings, and although it was not in every case separated from the lump, we can truthfully say that this 48 per cent., or 20,000,000 tons of screenings, was sold at the mine at an average price not to exceed two-thirds of its cost of production, and this same fine coal was used for making steam at an average efficiency of less than 50 per cent. These two facts are sufficient warrant for further investigation of this little known subject.

Maximum Bridge Stresses Under Live Load.

By R. M. Packard.

Many students beginning the subject of bridge stresses experience considerable difficulty in understanding fully the nature of the criteria for maximum bending moment and shear under moving loads; and also the exact circumstances under which they are satisfied. The theoretical treatment of the subject is not difficult, but is given in so little detail in the text books that a number of misconceptions are likely to arise in the mind of the beginner. It is hoped that the present paper may be of assistance in the mastery of the subject.

We will investigate the variations in bending moment at the third panel point from the right end of a single track through Pratt truss bridge, with seven panels of 25 ft. each, under Cooper's E 50 loading, which we will assume to come on from the right. In the development of the formulas letters will be used in order to make them general. The word "train" is to be understood to mean the uniform train load following the two locomotives.

Let l be the span, and l' the distance from the left support to the panel point under investigation (which will be called simply the panel point in what follows). Let P be the sum of all loads on the left of the panel point, and g the distance of their center of gravity from the panel point. Let Q be the sum of all the locomotive wheel loads on the truss and h the distance of their center of gravity from the head of the train. Let x be the length of train on the bridge, the weight of which on the truss will be w pounds per linear foot, or wx.

Then the left reaction is:

$$R = 1/l\ (Qh + Qx + \tfrac{1}{2}\,wx^2)$$

and the bending moment at the panel point is

$$M = Rl' - Pg$$
$$= l'/l\ (Qh + Qx + \tfrac{1}{2}\,wx^2) - Pg \ldots\ldots (1)$$

It will be of advantage at this time to note carefully the nature of the different quantities in Equation 1. In the case of bridges longer than the two coupled locomotives, Q and h will ordinarily be constant for all the maximum moments in the truss. The formulas for short bridges will be considered later. In the present investigation, then, Q and h can vary only when a wheel goes off the bridge at the left, and by considering the bending moment due to this wheel alone it will be seen that the discontinuity in Q and h can cause no discontinuity in M. The quantity x is continuous, and the product Pg will, in the manner indicated above, be seen to be continuous, although P and g change value discontinuously whenever a wheel crosses the panel point. The quantity M, then, is continuous and can be represented by a curve having values of M as ordinates and corresponding values of x as abscissas. Values of M when locomotive wheels are on the panel point, or are going off the bridge over the left support will be called critical values, and the corresponding points on the curve will be called critical points.

Between any two consecutive critical points all quantities in Equation 1 are either constant or continuous, and for any point on such a segment of the curve we can obtain a derivative dM/dx which will give the slope of the tangent to the curve at that point. If we note that g, as well as x, increases by dx as the loading moves a distance dx to the left, we obtain

$$dM/dx = \frac{l'}{l}/1\ (Q + wx) - P = \frac{l'}{l}\,W - P \quad (2)$$

where W is the total load on the bridge.

A consideration of Equation 2 shows that dM/dx is continuous between any two adjacent critical points, but that, as we approach a critical point along the curve dM/dx approaches in general two different limits according as we approach the point from one side or the other. These two values of dM/dx will be called "limiting values" for the critical point.

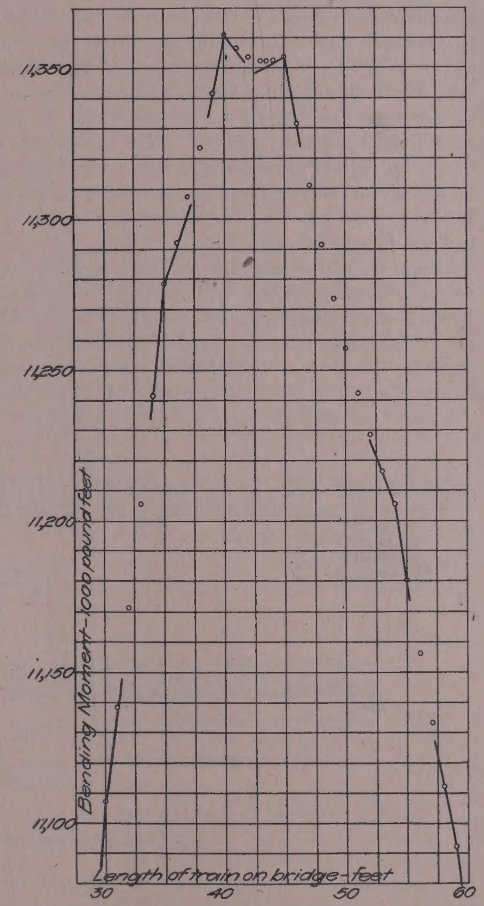


Diagram 1.

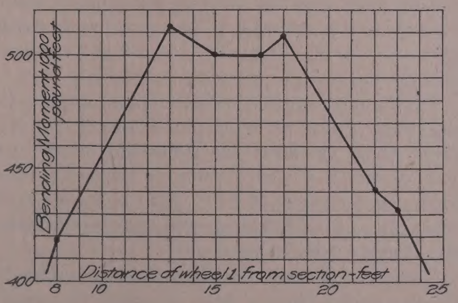


Diagram 2.

We may differentiate Equation 2, under the same limitations as before, obtaining

$$d^2M/dx^2 = \frac{l'}{l}\,w \ldots\ldots\ldots\ldots\ldots (3)$$

a positive constant for all segments of the curve. It is now clear that the quantity, M, can have no maxima of the ordinary form; that is, points on the curve with "horizontal tangents"—for the positive second derivative shows that all such points must be minima. But it will be seen that we may obtain an actual maximum at a critical point, provided that its two limiting values of dM/dx be of opposite sign, and that the resulting cusp on the curve points upward; more exactly, if we pass over a critical point in the direction in which x increases, dM/dx being positive before passing the point, and negative afterward, M will increase before passing the point, and decrease afterward, which will constitute a maximum. The behavior of the curve at these critical points is therefore to be carefully investigated.

For the particular case under consideration, $\frac{l'}{l} = 4/7$. We shall consider the range of values of M due to the presence of 30 to 59 ft. of train on the bridge. It will be found that none of the wheels run off the bridge, and that wheels 11 to 16 inclusive will run over the panel point. The limiting values of dM/dx, for each critical point, are shown in the following table:

Wheel at panel point.	Length of train on bridge, ft.	Limiting values of dM/dx.
11	30	$+55^5/_7$, $+30^5/_7$
12	35	$+37^6/_7$, $+12^6/_7$
13	40	$+20$ -5
None	43.5	00
14	45	$+2^1/_7$, $-22^6/_7$
15	54	$+10$, $-26\tfrac{1}{4}$
		$-19^3/_{28}$, $-35^{10}/_{28}$

The unit of weight is 1,000 lb. in all numerical work.

It will be observed that the two values corresponding to any position differ by the change in P at that position, or the load on the wheel which is then on the panel point. It will also be noticed that the continuous variation of dM/dx is uniform—at the rate of $\frac{l'}{l}\,w = 4/7 \times 2.5 = 1\ 3/7$ per foot; for example, the variation from $x = 30$ to $x = 35$ is $37\ 6/7 - 30\ 5/7 = 7\ 1/7 = 5xl\ 3/7$.

We, therefore, have cusps pointing upward when $x = 40$ and $x = 45$ and a minimum, with horizontal tangent, when $x = 43.5$.

In the accompanying Diagrams 1 are plotted values of M for each unit value of x from 30 to 59 and also the limiting tangents at the critical points. Similar curves will be found in some of the standard text books with horizontal tangents at the critical points, which is not theoretically justified.

Some interesting complications occur when we deal with a bridge or plate girder too short to include any of the uniform train load with the locomotive wheeel loads. The Equation 1 will not contain w, and will need other slight modifications, but the general principle involved in its derivation is quite the same.

Q, as before, represents the resultant of all the concentrated loads on the bridge, and is equal to W, the total load on the bridge. The quantity, h, is the distance of the point of application of Q, or center of gravity of W, from the right support. P, g, l and l' have their previous significations.

The bending moment of the section under investigation is, then:

$$M = \frac{l'}{l}\,Qh - Pg \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

and will be seen, by a little consideration, to be continuous, although the four quantities Q, P, h and g are discontinuous.

The differentiation of Equation 4 over a range of variation between two consecutive critical values, leads to the formula

$$dM/dx = \frac{l'}{l}\,Q - P \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

which is seen to be constant between each two consecutive critical points. This means, of course, that the "curve" representing M is composed solely of straight lines joined end to end at the critical points. It must be carefully borne in mind that a critical value occurs whenever Q, as well as P, experiences a discontinuity.

As an example we will investigate the middle section of a 30-ft. plate girder, under the same loading as before, for a range ot positions bringing wheels 2, 3, 4 and 5 at the section. The values of the slopes of the different straight lines composing the curve are given in Table I:

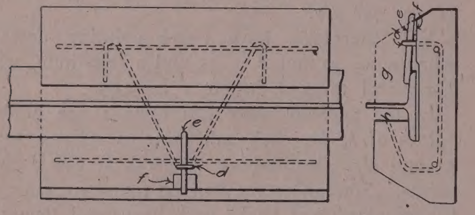
Table I.
Values of Slopes of Different Straight Lines Composing Curves Representing *M*.

Dist. of wheel (1) from section.	Wheel at section.	Wheel at support.	Values of $\frac{dM}{dx}$ or slopes.
8	2	5 right	+31.25, +18.75
13	3		+18.75, — 6.25
15		1 left	— 6.25, 0.00
17		6 right	0.00, + 8.125
18	4		+ 8.125, —16.875
22		7 right	—16.875, — 8.75
23	5	2 left	— 8.75, —21.25

It is evident that maxima occur when wheels 3 and 4 are at the section; Diagram 2, in which the values of *M* for the above range of values are plotted, exhibits all the details.

In a problem of this latter sort, when both Q and P become discontinuous at the same time, as will be seen to occur twice in the above range of values, the student sometimes has difficulty in ascertaining whether or not the criterion for maximum M is satisfied. If he keeps clearly in mind, however, that he is seeking a change of sign in the function 2 or 5, and not a fictitious equality between the numerical values of the positive and negative terms thereof, he will have no difficulty in analyzing correctly any case with which he may meet in either analytic or graphic work.

The investigation of maximum floor beam reactions in bridges is very similar to the last problem investigated, and the subject of maximum shears, when rigidly investigated, will be found to lead to conclusions similar to those of the first problem.



Detail of Beam Protection.

Of course practical considerations, such as the continuity of the rails, the riveting of stringers to floor beams and other details of construction, will change the shape of the curve at the critical points and modify the above results to some extent, but the purely theoretical points involved seem worthy of being thoroughly understood.

Recent Experiments in Balancing Engines, described in a paper by Prof. W. E. Dalby presented before the British Association, indicate that the two-cylinder-opposed type of engine, with cranks 180 deg. apart, so extensively used in automobile practice, may be balanced as to reciprocating parts with a greater degree of exactness than in any other form of engine mechanism. With the two-cylinder-opposed construction also very short connecting rods may be used with less objectionable results than in engines with cylinders not opposed. With the four-cylinder construction, it was shown that it is possible to so arrange the cranks and masses of the pistons that balancing in the horizontal direction can be accomplished completely, without, at the same time, introducing any unbalanced forces vertically. The balance between cranks of the four-cylinder vertical model was shown to be extremely delicate, a 10-deg. alteration of angle between middle cranks creating violent oscillations.

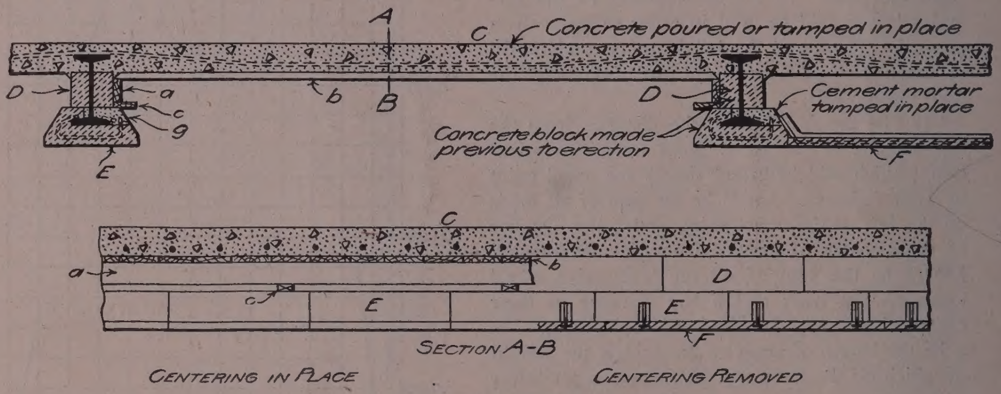
Letters to the Editor.

A System of Fireproof Floor Construction.

Sir:—A brief description of a new system of fireproof floor construction may possibly interest some of your readers: The floor slab in this system, as well as the fireproofing of the steel beams and girders may be built of cinder concrete or stone concrete, suitably reinforced. Briefly, the floor is constructed as follows:

Bottom flange blocks *E*, which are moulded in advance, are erected first. Recesses are cast in one side of these blocks, and the latter are reinforced with a bent and two straight bars, the bent bar forming a loop *d* in the middle and projecting above the top of the blocks on the side which is recessed away. The blocks are firmly secured to the steel beams or girders by driving a short steel bar *e* through the loop so that one end of the bar enters the top of the bottom flange of the steel beam, or girder, and the other end is supported by a short piece of band iron *f* which rests on top of the block. Cement grout is then filled in spaces *g* and *h*, thus embedding bar *e*, plate *f* and the looped bar *d*.

Blocks *D*, which are also moulded in advance, are now placed on top of blocks *E*, as shown. The wooden centering for the floor slab is erected next. This centering consists of timbers *a* placed on edge on top of wedges *c*, which are supported by the blocks *E*. The centering boards *b* for the concrete floor slab are now placed on top of timbers *a*. Intermediate supports for boards *b* are provided between the floor beams where required. The reinforcing metal for the floor slab is now put in place, and the concrete for same deposited on top of the centering. The wooden centering may be easily removed by first removing wedges *c*.


A
C
Concrete poured or tamped in place
D
a
c
g
E
b
B
D
Cement mortar tamped in place
Concrete block made previous to erection
F
C
a
b
D
c
E
E
F
Section A-B
Centering in Place
Centering Removed

Sections of Reinforced-Concrete Floor.

For floors requiring a flat ceiling, cement ceiling slabs *F* are moulded in advance. In these slabs small Tee-irons are embedded, to the bottom of which a wire netting is tied. The Tee-irons have their ends bent up to a bevel, which, when the ceiling slab is put in place, rests against the sloping sides of blocks *E*.

This floor system has been designed with the object of providing a floor in which the bottom flanges of the beams and girders are effectively protected against fire. Recent conflagrations have proved that it is not sufficient to rely on a thin coat of plaster, a piece of tile or a suspended ceiling for the protection of the most vital and the most exposed part of the floor system.

The wooden centering is extremely simple, and thus reduces to a minimum the amount of skilled carpenter work necessary to construct same. The amount of lumber required is also considerably less than is usual in this class of construction. Blocks *E* and *D* can be manufactured by common labor.

Yours truly,
A. Jordahl.

New York City, Aug. 20.

Oiling and Tarring Roads.

Sir: I have read with considerable interest the editorial in The Engineering Record for Aug. 25, last on the "Oiling and Tarring of Improved Roads," and also a few other articles on the same subject that have been published recently in your journal. Many highway and municipal engineers have become interested in the abatement of the dust nuisance on macadam roads, which has been aggravated so greatly of late by the wonderful increase in automobile traffic. While this traffic has perhaps not increased the dust on unimproved highways so noticeably as in the case of the macadam roads, the overcoming of the nuisance on such highways is often a matter of importance and convenience.

All descriptions of experiments on oiling and tarring roads that have come to my notice thus far have had to do in a large measure with tests made on improved roads. From what may be drawn from the published results of such tests it is quite evident that with a properly prepared roadbed, properly chosen oils or tar and a reasonable amount of care in the application of the latter, in most cases the formation of dust may be nearly overcome for a comparatively long period. It is to be questioned, however, whether satisfactory results could be secured in oiling or tarring a road having a natural surface of loamy soil, and apparently no such tests have been made. The great amount of data on the results of oiling natural road surfaces in California that has been published tends to show that the outcome of such work in that state have been almost uniformly successful in laying dust. These results cannot, however, be taken as indicative of what may be expected when oil is applied to a loamy soil in most sections of this country. This is due to several reasons, chief among which, in my opinion, is the fact that most of the roads that have been oiled in that state have a sandy soil surface. Reports have been published recently to the effect that a solution of calcium chloride has been sprinkled on roads in a section of England with highly satisfactory dust-laying results. It is said that the salt holds moisture absorbed from the atmosphere at night in sufficient quantities to avoid the formation of dust for some time after the application of solution. I am not aware whether any such experiments have been made in this country; and if they have I would be glad to know of them.

Very truly yours, John R. Holcombe.

Quincy, Ill., Aug. 31, 1906.

A Cement for Fastening iron to marble, which is said to give good results, may be made of 30 parts of plaster of Paris, 10 parts of iron filings and ½ part of sal ammoniac. It is mixed with vinegar to a fluid state, and, since it hardens if allowed to stand, is prepared for immmediate use.